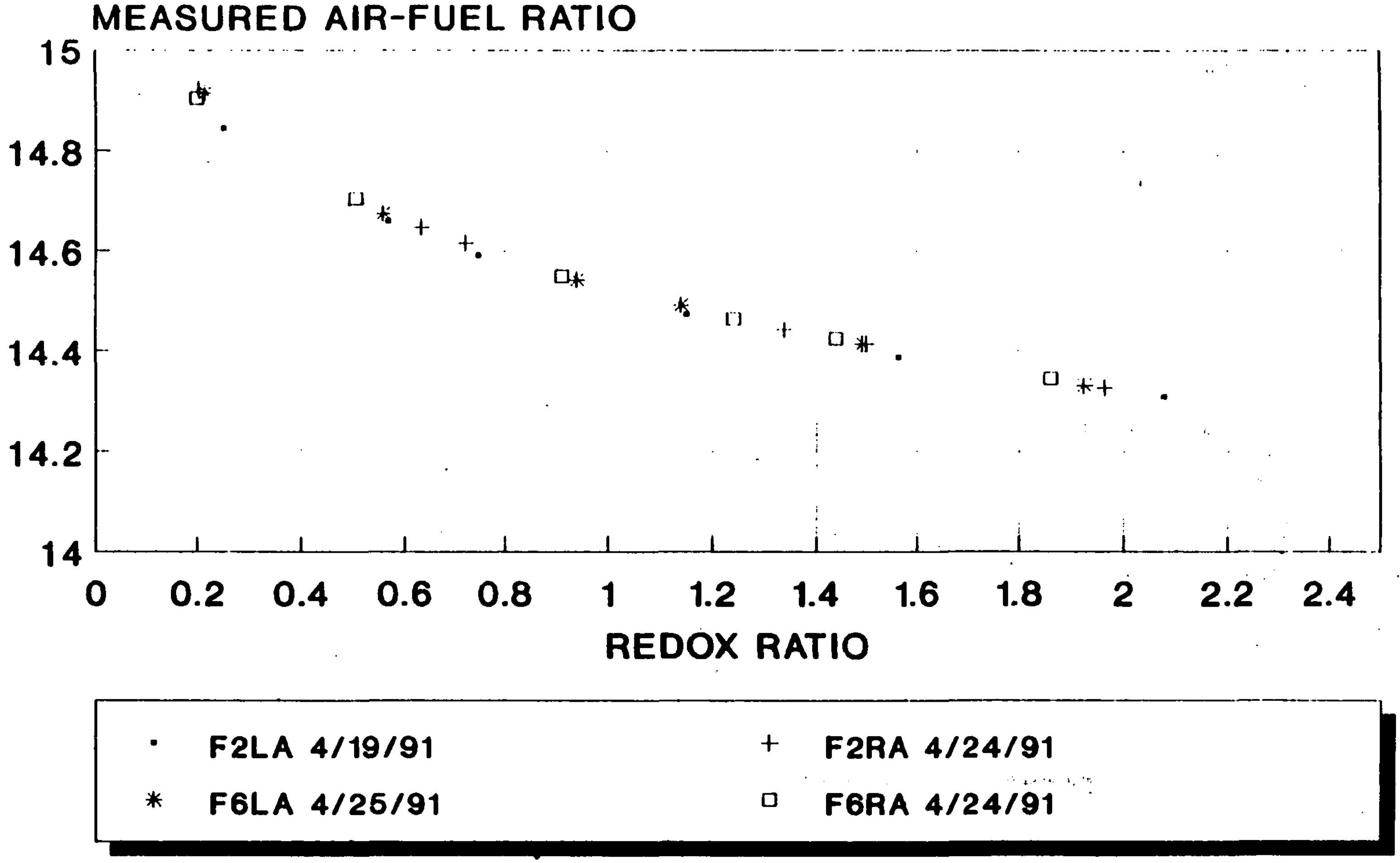
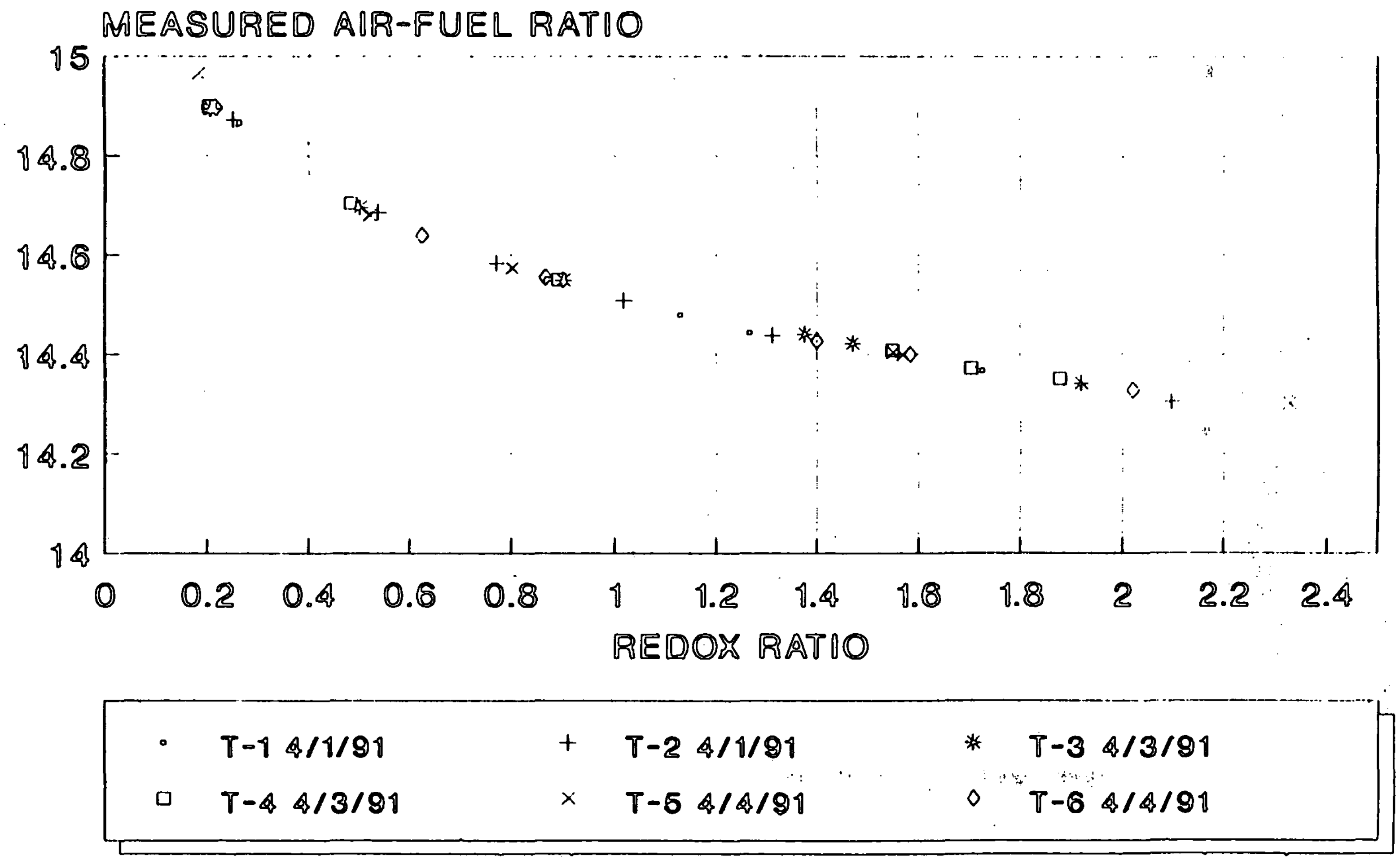
A/F RATIO

Catalysts F2LA, F2RA, F6LA and F6RA



A/F RATIO

Catalysts T-1 TO T-6



QA CONVERTER TEST RESULTS

Dirsbord 7/21/91

TEST NO.	TARGET AIR-FUEL RATIO	EXHAUST CONSTITUENTS AND UNITS	CATALYST INLET CONCENTRATION	50% CONVERSION LIGHT-OFF TIME, SEC	EFFICIENCY, %	REDOX RATIO
QA-2	14.49	HC, ppmC	259		87.3	0.764
5/2/91		LOW CO, ppm	0		99.5	
		CO, ppm	5377		99.8	
		NOX, ppm	1368		67.3	
		CO2, %	14			
		O2, %	0.5			
	14.37	HC, ppmC	314		84.4	1.178
		LOW CO, ppm	0		71.4	
		CO, ppm	6707		72.8	
		NOX, ppm	1368		80.3	
		CO2, %	14			
		O2, %	0.4			
	14.29	HC, ppmC	384		83.6	1.502
		LOW CO, ppm	0		100.0	
		CO, ppm	7936		50.7	
		NOX, ppm	1289		74.2	
		CO2, %	14			
		O2, %	0.3			
	14.18	HC, ppmC	499		78.4	2.048
		LOW CO, ppm	0		100.0	
		CO, ppm	10106		28.3	
		NOX, ppm	1289		67.3	
		CO2, %	14			
		O2, %	0.3			
	14.08	HC, ppmC	561		44.7	2.692
		LOW CO, ppm	0		100.0	
		CO, ppm	11855		16.2	
		NOX, ppm	1278		49.2	
		CO2, %	14			
		O2, %	0.3			
	13.97	HC, ppmC	823		28.3	3.629
		LOW CO, ppm	0		100.0	
		CO, ppm	14360		4.6	
		NOX, ppm	1140		22.2	
		CO2, %	14			
		O2, %	0.2			
	14.45	HC, ppmC	254	1.3	92.6	1.103
		LOW CO, ppm	0	2.0	97.6	
		CO, ppm	5668	2.0	94.0	
		NOX, ppm	1221	1.7	93.6	
		CO2, %	14			
		O2, %	0.3			

QA CONVERTER TEST RESULTS

7/21/91

TEST NO.	TARGET/ MEASURED AIR-FUEL RATIO	EXHAUST CONSTITUENTS AND UNITS	CATALYST INLET CONCENTRATION	50% CONVERSION LIGHT-OFF TIME, SEC	EFFICIENCY, %	REDOX RATIO
QA-2	14.55	HC, ppmC	324		94.6	0.852
5/15/91	14.57	LOW CO, ppm	0		99.5	
		CO, ppm	5961		99.6	
		NOX, ppm	1446		77.0	
		CO2, %	14.33			
		O2, %	0.45			
	14.45	HC, ppmC	374		90.0	1.160
	14.47	LOW CO, ppm	0		73.9	
		CO, ppm	6934		74.7	
		NOX, ppm	1413		81.8	
		CO2, %	14.33			
		O2, %	0.38			
	14.35	HC, ppmC	424		87.6	1.432
	14.40	LOW CO, ppm	0		100.0	
		CO, ppm	8093		54.2	
		NOX, ppm	1402		78.9	
		CO2, %	14.17			
		O2, %	0.35			
	14.25	HC, ppmC	499		84.5	1.869
	14.32	LOW CO, ppm	0		100.0	
		CO, ppm	8967		32.5	
		NOX, ppm	1379		66.7	
		CO2, %	14.17			
		O2, %	0.29			
	14.15	HC, ppmC	611		51.7	2.642
	14.18	LOW CO, ppm	0		100.0	
		CO, ppm	11235		14.5	
		NOX, ppm	1345		37.8	
		CO2, %	14.02			
		O2, %	0.25			
	14.05	HC, ppmC	698		34.4	3.426
	14.07	LOW CO, ppm	0		100.0	
		CO, ppm	13199		9.4	
		NOX, ppm	1232		19.9	
		CO2, %	13.87			
		O2, %	0.23			

QA CONVERTER TEST RESULTS

Printout 7/20/91

TEST NO.	TARGET/ MEASURED AIR-FUEL RATIO	EXHAUST CONSTITUENTS AND UNITS	CATALYST INLET CONCENTRATION	50% CONVERSION LIGHT-OFF TIME, SEC	EFFICIENCY, %	REDOX RATIO
QA-2	14.55	HC, ppmC	274		92.0	0.809
5/14/91	14.58	LOW CO, ppm	0		99.5	
		CO, ppm	5377		98.7	
		NOX, ppm	1345		68.7	
		CO2, %	14.33			
		O2, %	0.43			
	14.45	HC, ppmC	374		87.3	1.382
	14.42	LOW CO, ppm	0		100.0	
		CO, ppm	7625		56.8	
		NOX, ppm	1345		72.4	
		CO2, %	14.27			
		O2, %	0.34			
	14.35	HC, ppmC	386		86.5	1.566
	14.38	LOW CO, ppm	0		100.0	
		CO, ppm	7952		49.0	
		NOX, ppm	1390		74.2	
		CO2, %	14.33			
		O2, %	0.31			
	14.25	HC, ppmC	506		79.5	1.961
	14.29	LOW CO, ppm	0		100.0	
		CO, ppm	9696		27.6	
		NOX, ppm	1345		62.1	
		CO2, %	14.33			
		O2, %	0.30			
	14.15	HC, ppmC	611		35.8	2.990
	14.14	LOW CO, ppm	0		100.0	
		CO, ppm	12191		10.8	
		NOX, ppm	1232		21.9	
		CO2, %	14.17			
		O2, %	0.24			
	14.05	HC, ppmC	663		31.7	3.480
	14.07	LOW CO, ppm	0		100.0	
		CO, ppm	13449		7.2	
		NOX, ppm	1209		19.4	
		CO2, %	14.02			
		O2, %	0.23			

QA CONVERTER TEST RESULTS

TEST NO.	MEASURED AIR-FUEL RATIO	EXHAUST CONSTITUENTS AND UNITS	CATALYST INLET CONCENTRATION	50% CONVERSION LIGHT-OFF TIME, SEC	EFFICIENCY, %	REDOX RATIO
QA-2	14.55	HC, ppmC	299		93.0	0.700
5/16/91	14.63	LOW CO, ppm	0		99.3	
		CO, ppm	5377		97.8	
		NOX, ppm	1491		63.3	
		CO2, %	14.33			
		O2, %	0.50			
	14.45	HC, ppmC	394		89.5	1.227
	14.45	LOW CO, ppm	0		65.2	
		CO, ppm	7316		64.6	
		NOX, ppm	1390		72.4	
		CO2, %	14.24			
		O2, %	0.38			
	14.35	HC, ppmC	461		87.5	1.646
	14.36	LOW CO, ppm	0		100.0	
		CO, ppm	8631		41.9	
		NOX, ppm	1312		74.2	
		CO2, %	14.17			
		O2, %	0.33			
	14.25	HC, ppmC	499		81.7	2.010
	14.28	LOW CO, ppm	0		100.0	
		CO, ppm	9696		27.6	
		NOX, ppm	1357		67.1	
		CO2, %	14.02			
		O2, %	0.29			
	14.15	HC, ppmC	603		47.8	2.797
	14.16	LOW CO, ppm	0		100.0	
		CO, ppm	11754		17.3	
		NOX, ppm	1232		36.2	
		CO2, %	14.02			
		O2, %	0.25			
	14.05	HC, ppmC	685		35.8	3.244
	14.10	LOW CO, ppm	0		100.0	
		CO, ppm	13148		11.9	
		NOX, ppm	1221		23.6	
		CO2, %	14.17			
		O2, %	0.24			

Light Off Tests on Waiver Fleet Catalysts

Summary

The time to achieve 50% conversion of HC, CO, and NOX was determined for 24 catalysts taken from vehicles operated as part of Ethyl's 48-car test program. These tests showed no significant differences between HiTEC 3000 catalysts[1] and clear catalysts[1].

Introduction

These tests were conducted by Southwest Research Institute in San Antonio as part of a "post mortem" study of catalysts removed from waiver fleet cars. Although previous submissions utilized information from this SWRI study,[2] the light off results were not reported. This letter summarizes the light off time findings. A copy of the complete SWRI report will be made available to anyone desiring the report.

Test Procedure

The light-off test begins with the converter below 104°F, and the engine exhaust bypassing the converter. For these tests, the engine speed was set at 1,800 RPM, the A/F ratio was set at 14.45 and the fuel cycled plus and minus 0.5 A/F ratio about this setting, at a frequency of 1.0 hertz. When a stable engine exhaust temperature of 932°F was reached, the exhaust was switched to flow through the converter, using a quick-acting valve. Emission concentrations were measured continuously before and after the converter and the times to reach 50 percent conversion efficiency for HC, CO and NOX were calculated. Cars from which the catalysts were removed and tested are as follows:

Buick Century 2.8 L (H-1 through H-6) Same as B-7 thru B-12
Buick Century 3.8 L (I-1 thru I-6) Same as B-13 thru B-14
Escort 1.9 L (E-1 through E-6)
Crown Victoria 5.0 L (F2LA, F2RA, F6RA and F6LA)
Taurus 3.0 L (T-1 through T-6)

Results

Light off times are included as part of the detailed data for each catalyst (Tables 4 - 27), pages 12 through 35 of the final report. The light off times are shown in Table 1 for each car. Averages by fuel and pollutant are also presented. Light off times ranged from abut 10 to 35 seconds for hydrocarbons, 12 to 65[3] seconds for carbon monoxide and 11 to 31 seconds for nitrogen oxide as can be seen from Figure 1. Individual cars are shown by manufacturer in Figure 2 (Ford) and Figure 3 (General Motors). The clear Crown Victoria catalysts never reached 50% conversion and are so noted on Figures 1 and 2.

The rapidity of catalyst thermal activation (light off time) is a function of many variables other than the obvious one of catalyst activity. Flow geometry is one factor that might influence light off time; i.e. the entering gas jet effect may induce greater flow through the center of a monolith. However, perfect point-counterpoint examples exist in the light off results reported. The Ford Escort 1.9 L is equipped with a close coupled catalyst with side entering inlet flow (precludes any jet effect whatsoever). The Buick Century 2.8 L has the classic under the floorboard arrangement (jet effect is maximized). In neither of these cases is there a difference in light off times between clear and HiTEC 3000 exposed catalysts. This same analogy extends to any situation that would give localized flow increases through a monolith. Also note that flow rate and residence time are inversely related so that as localized flow increases the localized residence time decreases thereby reducing the amount of reactants converted.

General observations are that (1) light off times tend to be lower for HiTEC 3000 catalysts, (2) there is considerable variability within car models particularly for carbon monoxide data, (3) GM cars tend to have low light off times compared to Ford cars, and (4) the worst performing car is the Ford Escort. The data show that HiTEC 3000 does not adversely affect light off times.

[1]HiTEC 3000 catalyst is from cars which used HiTEC 3000 in the fuel -- clear catalyst is from cars which used clear fuel.

[2]In re Application for a Fuel Additive Waiver filed by Ethyl Corporation under Section 211(f)(4) of the Clean Air Act July 12, 1991, Appendix 7 ("Slave Engine Dynamometer Catalyst Studies at SWRI").

[3]A Crown Victoria catalyst from a clear fuel car did not achieve 50% conversion of carbon monoxide.

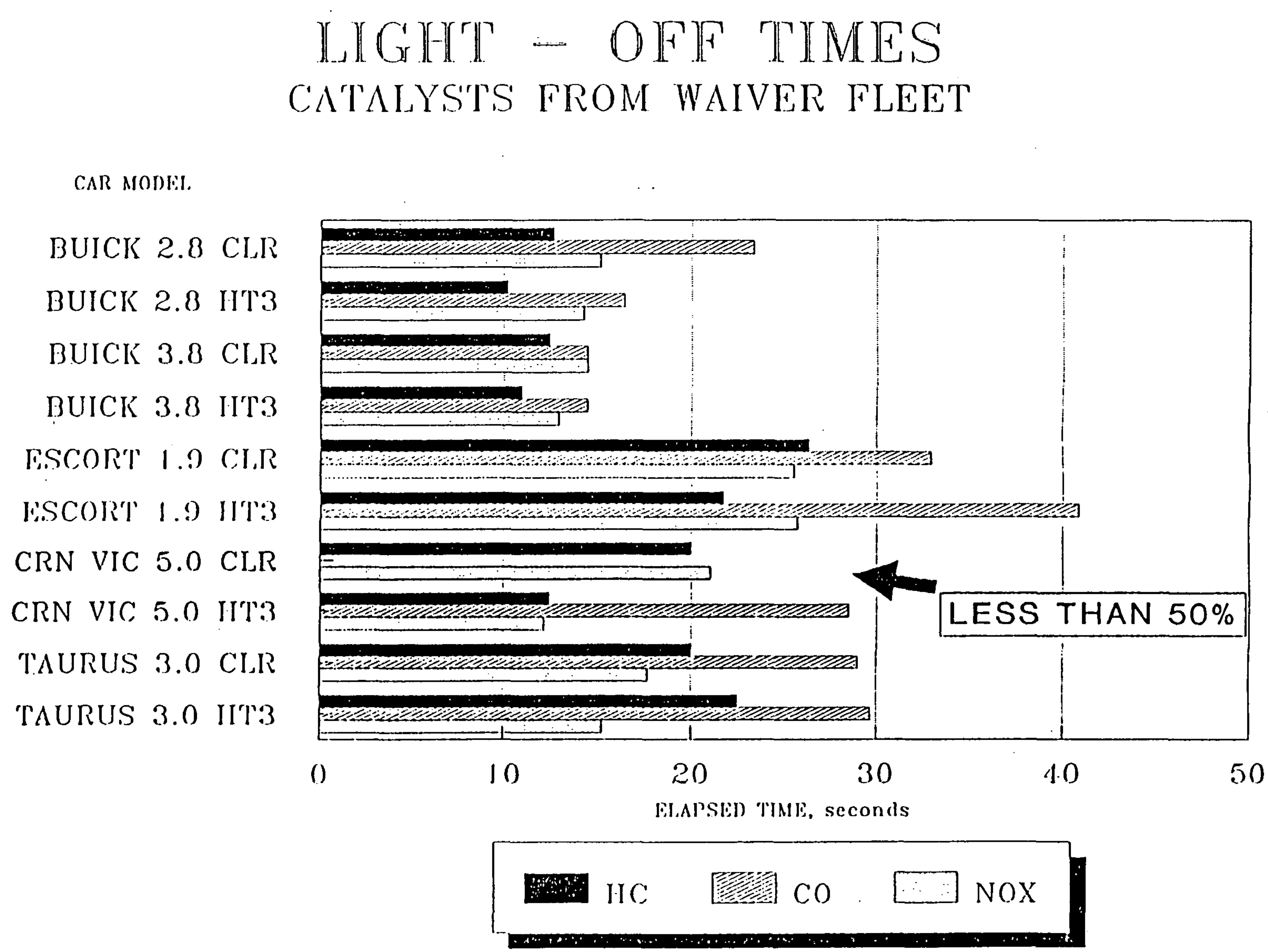
TABLE 1

Light Off Data

Buick Century 2.8 L	HC	CO	NOX
H-1 (C) Same as B-7	12.5	27.5	13.0
H-2 (C) Same as B-8	12.5	22.5	16.0
H-5 (C) Same as B-11	13.0	20.0	16.5
Mean (s.d.)	12.7 (.29)	23.3 (3.8)	15.2 (1.9)
H-3 (M) Same as B-9	9.5	18.0	18.5
H-4 (M) Same as B-10	10.0	12.5	12.5
H-6 (M) Same as B-12	11.0	19.0	12.0
Mean (s.d.)	10.2 (.76)	16.5 (3.5)	14.3 (3.6)
Buick Century 3.8 L			
I-1 (C) Same as B-13	12.5	14.5	14.5
I-2 (M) Same as B-14	11.0	14.5	13.0
Escort 1.9 L			
E-2 (C)	34.5	29.5	29.0
E-3 (C)	23.8	42.0	22.0
E-4 (C)	20.5	27.5	25.5
Mean (s.d.)	26.3 (7.30)	33.0 (7.86)	25.5 (3.50)
E-1 (M)	25.0	65.0	21.0
E-5 (M)	21.5	40.5	25.5
E-6 (M)	18.5	17.0	3.5
Mean (s.d.)	21.7 (3.25)	40.8 (24.00)	25.7 (4.75)
Crown Victoria 5.0 L			
F-6 (C)	19.5	did not achieve 50%	16.0
	20.0	did not achieve 50%	26.0
F-2 (M)	10.0	30.5	11.0
	15.0	26.5	13.5
Taurus 3.0 L			
T-2 (C)	20.5	21.0	21.0
T-3 (C)	19.0	30.0	18.0
T-6 (C)	20.5	36	14.0
Mean (s.d.)	20.0 (0.87)	29.0 (7.55)	17.7 (3.51)
T-1 (M)	15.5	19.5	11.8
T-4 (M)	25.0	46.0	16.5
T-5 (M)	27.0	23.5	17.5
Mean (s.d.)	22.5 (6.14)	29.7 (14.29)	15.3 (3.04)
	HC	**CO**	**NOX**
Grand Mean Clear	19.0	27.1	19.1
Grand Mean HiTEC 3000	17.0	27.6	17.4

*C - Clear Fuel
*M - HiTEC 3000 Fuel

FIGURE 1

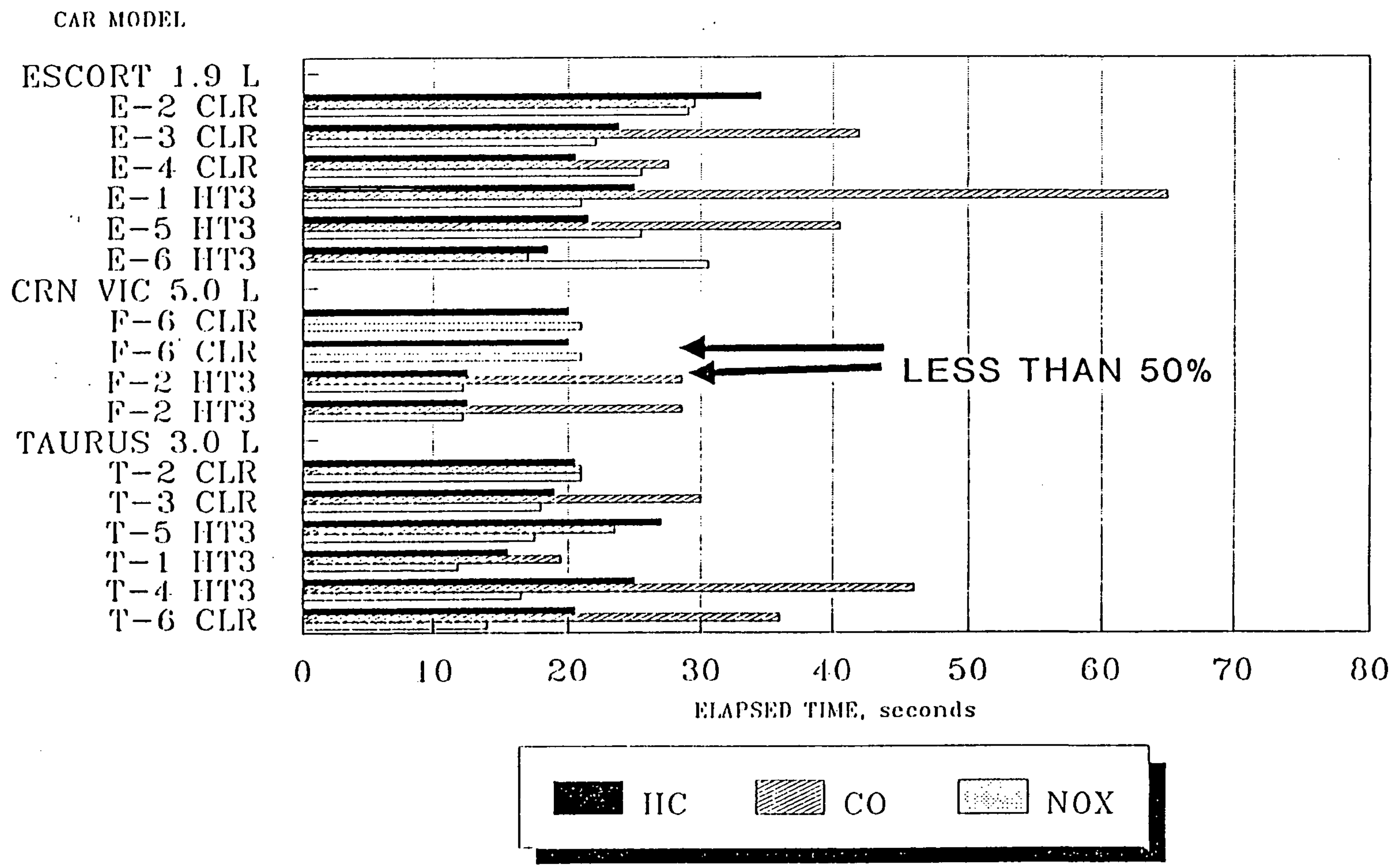


NOTE: Time to attain 50% conversion

FIGURE 2

LIGHT – OFF TIMES

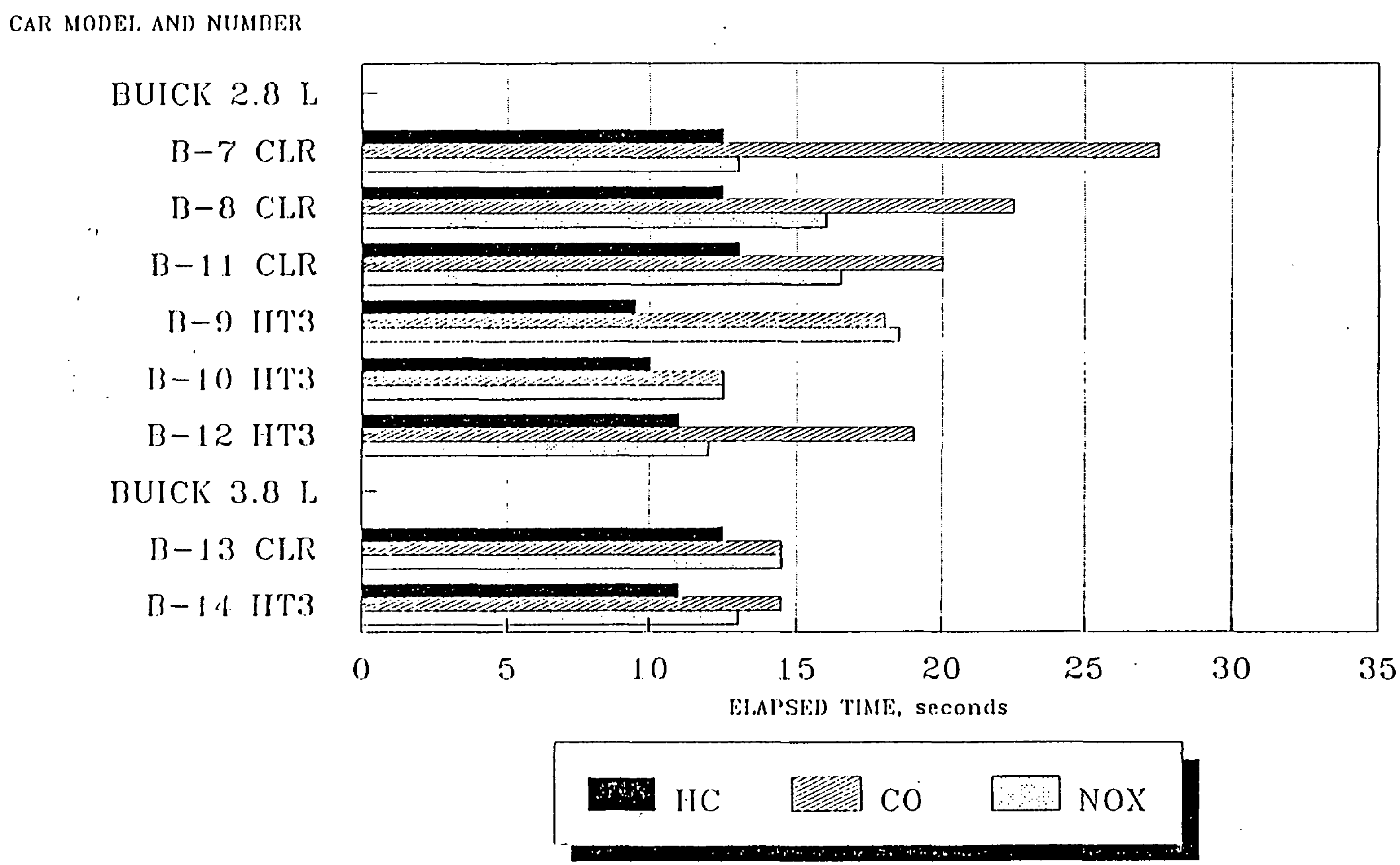
FORD CARS



NOTE: Time to attain 50% conversion

FIGURE 3

LIGHT - OFF TIMES
GENERAL MOTORS CARS



NOTE: Time to attain 50% conversion

Surface Area of Fleet Catalysts

Summary

The BET surface area was determined for samples removed from waiver fleet catalysts. These tests indicate no appreciable difference in surface area and indeed HiTEC 3000 catalyst averages were higher than clear catalysts.

Introduction

Surface area is an important indicator of activity for pollutant removal. As part of our "post mortem" of waiver fleet catalysts, the surface areas were determined by BET. Almost 200 separate measurements of surface area have been made. The information reported in this letter represents selected data from the study and is representative of the total data collection. The complete set of surface area measurements will be included in a subsequent study that will include complete metals analysis for each of the approximately 200 samples.

Test Procedure

All surface area measurements were done by the contract lab:

Quantachrome
5 Aerial Way
Syosset, NY 11791-9011
Telephone (516) 935-2240

Quantachrome is a well-known laboratory that specializes in particle and powder technology. The procedure is described in the attached letter.

Results

The surface areas of catalysts from five car models are shown in Table 1. The means and standard deviation are shown where multiple cars were tested. A grand mean for clear and HiTEC 3000 catalysts is computed and tabulated. One car model, the Crown Victoria, is shown separately because it was analyzed in five as opposed to three segments.

The surface areas for all cars are graphed in the figure entitled "Surface Area." The results are shown for segment x fuel groups.

The data reported herein do not show any degradation of the catalyst area attributable to HiTEC 3000 exposure. Indeed, the indications are that the inlet portion of HiTEC 3000 catalysts have slightly higher surface areas. This is not unexpected since the manganese oxide deposits themselves contribute to the existing surface area of the monolith. The fact that the inlet third which has the greatest amount of manganese oxide is somewhat higher in surface area strongly indicates that original catalyst surface area is intact and readily available. However, the range of variation between clear and HiTEC 3000 catalysts is well within the data spread and no enhancement nor degradation should be inferred from this data. Statistical comparisons will be possible when the data is complete.

072bff91

TABLE 1

Surface Area

Buick Century 2.8 L	**Inlet Third**		**Middle Third**		**Outlet Third**
H-2 (C) Same as B-8	13.7		18.4		21.2
H-5 (C) Same as B-11	19.0		24.8		25.1
Mean (s.d.)	16.3 (3.7)		21.6 (4.5)		23.2 (2.8)
H-4 (M) Same as B-10	16.5		17.0		17.7
H-6 (M) Same as B-12	25.8		22.6		20.7
Mean (s.d.)	21.2 (6.6)		20.0 (3.9)		19.2 (2.1)
Dodge Dynasty					
D-1 (C)	17.8		18.7		20.7
D-4 (M)	15.7		20.8		22.6
Escort 1.9 L					
E-2 (C)	14.4		11.1		17.7
E-3 (C)	22.9		20.7		22.1
E-4 (C)	13.7		19.4		20.7
Mean (s.d.)	17.0 (5.11)		17.1 (5.2)		20.2 (2.2)
E-1 (M)	16.0		19.8		23.5
E-5 (M)	13.7		14.7		18.9
E-6 (M)	17.6		18.9		22.7
Mean (s.d.)	15.8 (2.0)		17.8 (2.7)		21.7 (2.5)
Taurus 3.0 L					
T-2 (C)	15.8		23.9		26.0
T-3 (C)	18.8		21.3		20.2
T-6 (C)	17.6		18.9		22.7
Mean (s.d.)	17.4 (1.5)		21.4 (2.5)		23.0 (2.9)
T-1 (M)	20.8		21.3		22.9
T-4 (M)	22.3		25.8		21.6
T-5 (M)	23.9		22.3		22.0
Mean (s.d.)	22.3 (1.6)		23.1 (2.4)		22.2 (0.7)
	Inlet Third		**Middle Third**		**Outlet Third**
Grand Mean Clear	17.1		19.7		21.8
Grand Mean HiTEC 3000	19.1		20.4		21.4
Crown Victoria 5.0 L	First 20%	Second 20%	Third 20%	Fourth 20%	Fifth 20%
F-6 (C)	9.2	13.7	21.0	20.5	14.8
F-2 (M)	12.5	18.4	21.3	20.5	22.1

*C - Clear Fuel
*M - HiTEC 3000 Fuel

SURFACE AREA
CATALYSTS FROM WAIVER FLEET

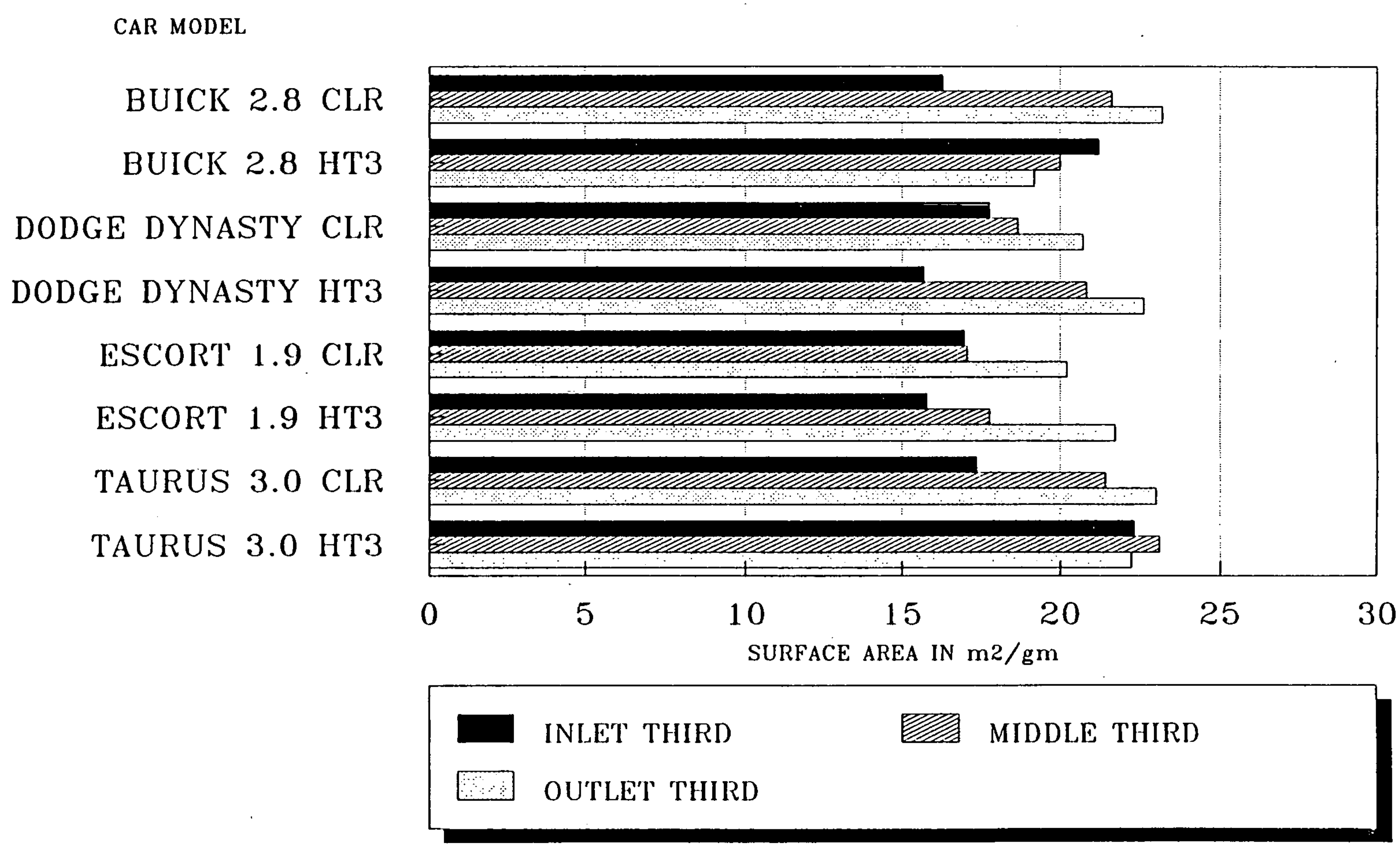


Figure 1

NOTE: SUFACE AREA IN m2/gm

ATTACHMENT

QUANTACHROME
FIRST IN POWDER TECHNOLOGY

5 Aerial Way, P.O. Box 9011
Syosset, New York 11791-9011
Phone: 516-935-2240
Fax: 516-935-2194
Telex: 510 221 2239

November 4, 1991

Ethyl Corporation
Gulf States Road
Baton Rouge, LA 70805

Attention: Allen A. Aradi

Dear Dr. Aradi,

As per our telephone conversation, I am outlining below, the procedure used to measure the surface area of your samples.

1. A clean, dry sample cell is weighed and the tare weight is noted.

2. Approximately ½ gram of sample is placed into the cell and the cell is attached to a cell holder.

3. The cell holder and cell are connected to a QUANTECTOR outgassing unit and the sample is heated to 300°C with clean helium flowing through the cell until the built-in detector indicates that the sample is clean.

4. The cell holder, cell and sample are then moved to one of several calibrated MONOSORBS for surface area measurement by nitrogen adsorption. A relative pressure P/P_0 of 0.3 is used for the test. The total surface area is read directly from the front panel of the MONOSORB.

5. Each sample is tested twice and the average of the two tests is used to calculate the final results.

6. The sample cell and sample are weighed after the test, and the tare weight is subtracted. This net sample weight is divided into the average total surface area to determine the specific surface area. The net sample weight, total surface area and specific surface area are included in the report.

I hope this is the information that you need. If you have any questions, lese feel free to call me.

David M. Seltzer

David M. Seltzer
Manager, Customer Services

Systems Applications International

101 Lucas Valley Road San Rafael, CA 94903
415-507-7100 Facsimile 415-507-7177
A Division of Clement International Corporation
Environmental and Health Sciences

MEMORANDUM

TO: Dave Kortum and John Holly, EPA/OMS

FROM: Alison Pollack

SUBJECT: Data and analysis requests from Ethyl HiTEC 3000 testing data

DATE: 4 November 1991

In our conference call of 31 October 1991 with Ethyl Corporation, you requested data listings of average hydrocarbon concentrations and regression analyses of specific data sets based on Ethyl's HiTEC 3000 fleet testing program. The attachments to this memo contain all of the information you requested.

Attachment 1 contains a listing of the average hydrocarbon emissions as plotted in Figures B-49 through B-52 of Appendix 2A (SAI's analyses) to Ethyl's 9 May 1990 waiver application. Averages are listed for each fuel (Howell EEE or HiTEC 3000) within each of the eight models in Ethyl's 48-car fleet. As noted on the listing, these averages are from data set ETHYL4S2, which was the data set used in the majority of SAI's analyses.

Ethyl's protocol called for two FTP tests at each 5,000 mile testing interval for all vehicles. In some cases an additional test (or tests) were performed, if the first two tests resulted in a large difference in emission rates. In creating data set ETHYL4S from data set ETHYL3S, as described on page 12 of SAI's report, 151 such extra tests were deleted. Pages 13 to 15 of SAI's report describe testing associated with component changes at 50,000 miles. Because some significant changes in emissions occurred after component changes, all FTP tests performed after the two standard 50,000 mile interval tests (before component changes) were excluded to create data set ETHYL4S2, which was used in all of SAI's statistical analyses. Therefore, of the 151 tests excluded to create ETHYL4S from ETHYL3S, some are not extra to the first two before component changes. Eighteen tests fall into this category; they are listed and described in Attachment 2. Almost all of the tests listed in Attachment 2 are extra tests performed in addition to the standard two after component changes. The two exceptions are for vehicles D5 and H6; the three tests listed for these two vehicles correspond to extra tests performed in addition to the standard two after unscheduled maintenance. While in general tests after unscheduled maintenance were not excluded from analysis (though tests before unscheduled maintenance were), such tests were excluded in creating data set ETHYL4S2 from ETHYL4S. Because of the complexity of the types of tests performed at the 50,000 mile interval, the software for the creation of data set ETHYL4S2 selected only those 50,000 mile tests coded as preceding component changes. In addition, all of our software defines the testing interval to be plus or minus 2500 miles of the 5000 mile interval. The single test for vehicle H6 and the two tests for vehicle D5 in Attachment 2 are all extra tests for unscheduled maintenance occurring in the 50,000 mile interval (i.e., 47,500 to 52,500 miles), and were therefore excluded in the creation of ETHYL4S2.

We have now created a new data set, which we refer to as ETHYL3S2, which contains the 1814 tests in data set ETHYL4S2 and the 133 (= 151 - 18) extra tests for that subset of ETHYL4S. We performed the 50,000 mile and 75,000 mile linear regressions on data set ETHYL3S2, the same as had previously been performed on data set ETHYL4S2. Attachments 3 through 6 provide the full set of linear regressions as follows:

Attachment 3	50,000 mile linear regression on data set ETHYL4S2
Attachment 4	50,000 mile linear regression on data set ETHYL3S2
Attachment 5	75,000 mile linear regression on data set ETHYL4S2
Attachment 6	75,000 mile linear regression on data set ETHYL3S2

The first page of each of these four attachments is a summary table of the fitted regression lines with the intercept ("0 miles), the slope (referred to as the deterioration rate), the fitted value at 50,000 miles, and the fitted value at 75,000 miles (in Attachments 5 and 6 only). This page is then followed by eight pages, one per model, of detailed regression output from SAS for the EEE vehicles and then for the HiTEC 3000 vehicles. This detailed output includes the analysis of variance table as you requested. However, a test for a statistically significant change in slope with the addition of the extra tests is a non-trivial test because the two regression equations are highly dependent.

Although we have not performed the statistical comparison of the two sets of regression slopes, one can nonetheless draw somewhat qualitative conclusions based on the standard errors about the regression coefficients, and based on the comparisons of the predictions at 50,000 (and 75,000) miles. The changes in the deterioration rates and the changes in the 50,000 mile and 75,000 mile predictions are all very small, and appear to be within the noise. In virtually all cases the predicted difference between EEE and HiTEC 3000 vehicles is decreased in the ETHYL3S2 analysis from the ETHYL4S2 analysis. In addition, the weighted average results at the bottom of each summary table show that the predicted differences between HiTEC 3000 and EEE decrease with the addition of these 131 tests. In other words, the addition of the extra tests, if anything, is in Ethyl's favor.

akp9273

ATTACHMENT 1

Average hydrocarbon emissions (g/mile) from data set ETHYL4S2

Fuel	Mileage Interval	HC D	HC E	HC F	HC T	HC C	HC G	HC H	HC I
EEE	1	0.281	0.099	0.168	0.189	0.123	0.101	0.182	0.173
EEE	5	0.304	0.131	0.246	0.231	0.143	0.113	0.190	0.170
EEE	10	0.334	0.155	0.331	0.245	0.166	0.120	0.223	0.171
EEE	15	0.373	0.148	0.386	0.278	0.158	0.106	0.230	0.190
EEE	20	0.441	0.156	0.399	0.280	0.190	0.136	0.277	0.184
EEE	25	0.454	0.158	0.480	0.305	0.179	0.140	0.281	0.223
EEE	30	0.570	0.171	0.583	0.302	0.175	0.146	0.294	0.175
EEE	35	0.575	0.163	0.555	0.335	0.206	0.136	0.321	0.191
EEE	40	0.554	0.196	0.586	0.418	0.175	0.139	0.300	0.176
EEE	45	0.639	0.233	0.688	0.402	0.184	0.138	0.312	0.178
EEE	50	0.605	0.212	0.729	0.446	0.183	0.123	0.345	0.195
EEE	55	0.758	0.218	0.564	0.392	0.198	0.146	0.390	0.183
EEE	60	0.705	0.245	0.593	0.366	0.181	0.130	0.420	0.187
EEE	65	0.696	0.294	0.580	0.457	0.177	0.148	0.424	0.181
EEE	70	0.594	0.223	0.583	0.398	0.208	0.164	0.378	0.214
EEE	75	0.678	0.246	0.476	0.433	0.202	0.161	0.389	0.190
HiTEC	1	0.279	0.104	0.167	0.207	0.129	0.100	0.168	0.162
HiTEC	5	0.318	0.161	0.253	0.257	0.159	0.117	0.208	0.174
HiTEC	10	0.354	0.181	0.349	0.297	0.197	0.130	0.209	0.183
HiTEC	15	0.421	0.190	0.405	0.291	0.204	0.142	0.242	0.212
HiTEC	20	0.519	0.202	0.422	0.328	0.239	0.172	0.265	0.187
HiTEC	25	0.514	0.184	0.458	0.346	0.214	0.173	0.258	0.193
HiTEC	30	0.625	0.195	0.606	0.372	0.220	0.179	0.298	0.200
HiTEC	35	0.645	0.191	0.576	0.398	0.256	0.182	0.275	0.191
HiTEC	40	0.635	0.234	0.569	0.437	0.239	0.182	0.296	0.194
HiTEC	45	0.646	0.193	0.611	0.431	0.228	0.171	0.351	0.203
HiTEC	50	0.721	0.194	0.693	0.454	0.220	0.153	0.337	0.194
HiTEC	55	0.655	0.210	0.555	0.429	0.226	0.169	0.398	0.194
HiTEC	60	0.649	0.239	0.630	0.410	0.205	0.169	0.481	0.194
HiTEC	65	0.742	0.267	0.616	0.411	0.212	0.189	0.460	0.200
HiTEC	70	0.578	0.226	0.599	0.398	0.254	0.186	0.408	0.216
HiTEC	75	0.621	0.241	0.613	0.400	0.235	0.197	0.412	0.216

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ATTACHMENT 2

Tests NOT To Be Added back to ETHYL4S2

OBS	Model	Vehicle ID	Fuel	Mileage	HC (g/mi)	CO (g/mi)	NOx (g/mi)
1	D	D4	HT3	50,166	0.581	3.490	0.417
2	D	D4	HT3	50,184	0.607	3.619	0.384
3	D	D5	HT3	48,433	0.924	4.960	0.441
4	D	D5	HT3	48,444	0.796	4.617	0.404
5	E	E2	EEE	50,181	0.323	7.928	0.531
6	F	F5	EEE	50,118	0.596	2.253	0.978
7	F	F5	EEE	50,166	0.618	1.939	1.037
8	G	G1	EEE	51,110	0.137	3.234	0.395
9	G	G3	HT3	51,110	0.183	2.248	0.390
10	G	G4	EEE	51,104	0.132	2.194	0.365
11	G	G5	HT3	51,132	0.283	2.192	0.357
12	G	G6	HT3	51,118	0.169	2.350	0.369
13	H	H6	HT3	50,688	0.428	4.908	0.388
14	I	I1	EEE	50,379	0.167	2.768	0.438
15	I	I2	HT3	50,278	0.212	2.401	0.301
16	I	I4	HT3	50,431	0.158	2.329	0.311
17	I	I5	EEE	50,386	0.176	2.240	0.428
18	I	I6	HT3	50,326	0.182	2.123	0.604

ATTACHMENT 3

Ethyl Corporation HiTEC 3000 Fleet Testing Program
0-50k Data Analyzed

Fitted Regression Lines
Data Set ETHYL4S2
Pollutant Hydrocarbons

Model	Fuel	0 Miles (g/mi)	50k Miles (g/mi)	Deterioration Rate(a) (rate/10,000 mi)
D	HT3	0.2895	0.7469	0.0915
	EEE	0.2743	0.6615	0.0774
E	HT3	0.1512	0.2181	0.0134
	EEE	0.1128	0.2170	0.0208
F	HT3	0.2270	0.7149	0.0976
	EEE	0.2010	0.7432	0.1084
T	HT3	0.2271	0.4663	0.0478
	EEE	0.1896	0.4273	0.0476
C	HT3	0.1666	0.2524	0.0172
	EEE	0.1448	0.1967	0.0104
G	HT3	0.1221	0.1895	0.0135
	EEE	0.1121	0.1444	0.0064
H	HT3	0.1836	0.3501	0.0333
	EEE	0.1895	0.3465	0.0314
I	HT3	0.1771	0.2047	0.0055
	EEE	0.1771	0.1894	0.0025
Wtd Ave (b)	HT3	0.1875	0.3657	0.0356
	EEE	0.1731	0.3484	0.0351

Notes:

a. The deterioration rate is the rate of increase per 10,000 miles (slope of the regression line).

b. The weights for the weighted averages are proportional to 1988 sales figures.

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0-50k Data Analyzed
Data Set ETHYL4S2

------------------------------ MODEL=C FUEL=EEE ------------------------------

Model: MODEL1
Dependent Variable: HC HC Composite Emissions (g/mi)

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	1	0.01764	0.01764	26.009	0.0001
Error	70	0.04747	0.00068		
C Total	71	0.06511			

Root MSE	0.02604	R-square	0.2709
Dep Mean	0.17129	Adj R-sq	0.2605
C.V.	15.20343		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	0.144770	0.00603848	23.975	0.0001
MILES	1	0.010389	0.00203711	5.100	0.0001

------------------------------ MODEL=C FUEL=HT3 ------------------------------

Model: MODEL1
Dependent Variable: HC HC Composite Emissions (g/mi)

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	1	0.04823	0.04823	40.027	0.0001
Error	72	0.08675	0.00120		
C Total	73	0.13498			

Root MSE	0.03471	R-square	0.3573
Dep Mean	0.21051	Adj R-sq	0.3484
C.V.	16.48898		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	0.166556	0.00803473	20.729	0.0001
MILES	1	0.017166	0.00271325	6.327	0.0001

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0-50k Data Analyzed
Data Set ETHYL4S2

------------------------- MODEL=D FUEL=EEE -------------------------

Model: MODEL1
Dependent Variable: HC   HC Composite Emissions (g/mi)

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	1	0.67048	0.67048	267.532	0.0001
Error	46	0.11528	0.00251		
C Total	47	0.78577			

Root MSE	0.05006	R-square	0.8533
Dep Mean	0.47531	Adj R-sq	0.8501
C.V.	10.53239		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	0.274307	0.01425600	19.242	0.0001
MILES	1	0.077441	0.00473457	16.356	0.0001

------------------------- MODEL=D FUEL=HT3 -------------------------

Model: MODEL1
Dependent Variable: HC   HC Composite Emissions (g/mi)

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	1	1.40237	1.40237	304.781	0.0001
Error	70	0.32209	0.00460		
C Total	71	1.72445			

Root MSE	0.06783	R-square	0.8132
Dep Mean	0.52669	Adj R-sq	0.8106
C.V.	12.87887		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	0.289458	0.01576598	18.360	0.0001
MILES	1	0.091484	0.00524026	17.458	0.0001

Ethyl Corporation HiTEC 3000 Fleet Testing Program
0-50k Data Analyzed
Data Set ETHYL4S2

---------------------------- MODEL=E FUEL=EEE ----------------------------

Model: MODEL1
Dependent Variable: HC   HC Composite Emissions (g/mi)

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	1	0.07118	0.07118	61.154	0.0001
Error	70	0.08148	0.00116		
C Total	71	0.15266			

Root MSE	0.03412	R-square	0.4663
Dep Mean	0.16600	Adj R-sq	0.4587
C.V.	20.55272		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	0.112765	0.00790617	14.263	0.0001
MILES	1	0.020847	0.00266586	7.820	0.0001

---------------------------- MODEL=E FUEL=HT3 ----------------------------

Model: MODEL1
Dependent Variable: HC   HC Composite Emissions (g/mi)

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	1	0.02931	0.02931	36.485	0.0001
Error	70	0.05624	0.00080		
C Total	71	0.08555			

Root MSE	0.02834	R-square	0.3426
Dep Mean	0.18536	Adj R-sq	0.3332
C.V.	15.29166		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	0.151179	0.00657146	23.005	0.0001
MILES	1	0.013393	0.00221725	6.040	0.0001

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Data Set ETHYL4S2

---------------------------- MODEL=F FUEL=EEE ----------------------------

Model: MODEL1
Dependent Variable: HC HC Composite Emissions (g/mi)

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	1	1.92144	1.92144	430.920	0.0001
Error	70	0.31212	0.00446		
C Total	71	2.23357			

Root MSE	0.06678	R-square	0.8603
Dep Mean	0.47775	Adj R-sq	0.8583
C.V.	13.97701		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	0.200961	0.01548279	12.980	0.0001
MILES	1	0.108448	0.00522425	20.759	0.0001

---------------------------- MODEL=F FUEL=HT3 ----------------------------

Model: MODEL1
Dependent Variable: HC HC Composite Emissions (g/mi)

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	1	1.55828	1.55828	474.803	0.0001
Error	70	0.22974	0.00328		
C Total	71	1.78802			

Root MSE	0.05729	R-square	0.8715
Dep Mean	0.47604	Adj R-sq	0.8697
C.V.	12.03432		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	0.227009	0.01327403	17.102	0.0001
MILES	1	0.097582	0.00447830	21.790	0.0001

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0-50k Data Analyzed
Data Set ETHYL4S2

------------------------- MODEL=G FUEL=EEE -------------------------

Model: MODEL1
Dependent Variable: HC HC Composite Emissions (g/mi)

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	1	0.00679	0.00679	17.258	0.0001
Error	70	0.02754	0.00039		
C Total	71	0.03433			

Root MSE	0.01984	R-square	0.1978
Dep Mean	0.12858	Adj R-sq	0.1863
C.V.	15.42580		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	0.112131	0.00459874	24.383	0.0001
MILES	1	0.006444	0.00155120	4.154	0.0001

------------------------- MODEL=G FUEL=HT3 -------------------------

Model: MODEL1
Dependent Variable: HC HC Composite Emissions (g/mi)

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	1	0.02972	0.02972	43.296	0.0001
Error	70	0.04804	0.00069		
C Total	71	0.07776			

Root MSE	0.02620	R-square	0.3822
Dep Mean	0.15651	Adj R-sq	0.3733
C.V.	16.73832		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	0.122096	0.00607391	20.102	0.0001
MILES	1	0.013477	0.00204823	6.580	0.0001

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Ethyl Corporation HiTEC 3000 Fleet Testing Program
0-50k Data Analyzed
Data Set ETHYL4S2

------------------------- MODEL=H FUEL=EEE -------------------------

Model: MODEL1
Dependent Variable: HC HC Composite Emissions (g/mi)

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	1	0.16415	0.16415	170.461	0.0001
Error	72	0.06933	0.00096		
C Total	73	0.23348			

Root MSE	0.03103	R-square	0.7030
Dep Mean	0.27073	Adj R-sq	0.6989
C.V.	11.46226		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	0.189514	0.00719086	26.355	0.0001
MILES	1	0.031395	0.00240463	13.056	0.0001

------------------------- MODEL=H FUEL=HT3 -------------------------

Model: MODEL1
Dependent Variable: HC HC Composite Emissions (g/mi)

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	1	0.18206	0.18206	99.716	0.0001
Error	72	0.13145	0.00183		
C Total	73	0.31351			

Root MSE	0.04273	R-square	0.5807
Dep Mean	0.26923	Adj R-sq	0.5749
C.V.	15.87078		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	0.183629	0.00990735	18.535	0.0001
MILES	1	0.033290	0.00333378	9.986	0.0001

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Ethyl Corporation HiTEC 3000 Fleet Testing Program
0-50k Data Analyzed
Data Set ETHYL4S2

------------------------------ MODEL=I FUEL=EEE ------------------------------

Model: MODEL1
Dependent Variable: HC HC Composite Emissions (g/mi)

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	1	0.00099	0.00099	1.251	0.2671
Error	70	0.05540	0.00079		
C Total	71	0.05639			

Root MSE	0.02813	R-square	0.0176
Dep Mean	0.18336	Adj R-sq	0.0035
C.V.	15.34237		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	0.177079	0.00652181	27.152	0.0001
MILES	1	0.002460	0.00219963	1.119	0.2671

------------------------------ MODEL=I FUEL=HT3 ------------------------------

Model: MODEL1
Dependent Variable: HC HC Composite Emissions (g/mi)

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	1	0.00520	0.00520	8.053	0.0059
Error	72	0.04652	0.00065		
C Total	73	0.05173			

Root MSE	0.02542	R-square	0.1006
Dep Mean	0.19161	Adj R-sq	0.0881
C.V.	13.26630		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	0.177108	0.00590244	30.006	0.0001
MILES	1	0.005515	0.00194324	2.838	0.0059

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Ethyl Corporation HiTEC 3000 Fleet Testing Program
0-50k Data Analyzed
Data Set ETHYL4S2

---------------------------- MODEL=T FUEL=EEE ----------------------------

Model: MODEL1
Dependent Variable: HC HC Composite Emissions (g/mi)

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	1	0.36925	0.36925	312.368	0.0001
Error	70	0.08275	0.00118		
C Total	71	0.45199			

Root MSE	0.03438	R-square	0.8169
Dep Mean	0.31089	Adj R-sq	0.8143
C.V.	11.05908		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	0.189553	0.00797180	23.778	0.0001
MILES	1	0.047551	0.00269043	17.674	0.0001

---------------------------- MODEL=T FUEL=HT3 ----------------------------

Model: MODEL1
Dependent Variable: HC HC Composite Emissions (g/mi)

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	1	0.37248	0.37248	313.997	0.0001
Error	70	0.08304	0.00119		
C Total	71	0.45552			

Root MSE	0.03444	R-square	0.8177
Dep Mean	0.34915	Adj R-sq	0.8151
C.V.	9.86452		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	0.227085	0.00799565	28.401	0.0001
MILES	1	0.047833	0.00269941	17.720	0.0001

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ATTACHMENT 4

Ethyl Corporation HiTEC 3000 Fleet Testing Program
0-50k Data Analyzed

Fitted Regression Lines
Data Set ETHYL3S2
Pollutant Hydrocarbons

Model	Fuel	0 Miles (g/mi)	50k Miles (g/mi)	Deterioration Rate(a) (rate/10,000 mi)
D	HT3	0.2928	0.7372	0.0889
	EEE	0.2735	0.6635	0.0780
E	HT3	0.1515	0.2175	0.0132
	EEE	0.1118	0.2194	0.0215
F	HT3	0.2322	0.7060	0.0948
	EEE	0.2015	0.7409	0.1079
T	HT3	0.2247	0.4697	0.0490
	EEE	0.1890	0.4287	0.0479
C	HT3	0.1719	0.2477	0.0152
	EEE	0.1475	0.1943	0.0094
G	HT3	0.1221	0.1895	0.0135
	EEE	0.1104	0.1473	0.0074
H	HT3	0.1833	0.3518	0.0337
	EEE	0.1885	0.3479	0.0319
I	HT3	0.1800	0.2034	0.0047
	EEE	0.1770	0.1885	0.0023
Wtd Ave (b)	HT3	0.1890	0.3642	0.0350
	EEE	0.1729	0.3488	0.0352

Notes:
a. The deterioration rate is the rate of increase per 10,000 miles (slope of the regression line).
b. The weights for the weighted averages are proportional to 1988 sales figures.

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Ethyl Corporation HiTEC 3000 Fleet Testing Program

0-50k Data Analyzed
Data Set ETHYL3S2

MODEL=C FUEL=EEE

Model: MODEL1
Dependent Variable: HC HC Composite Emissions (g/mi)

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	1	0.01499	0.01499	20.138	0.0001
Error	77	0.05731	0.00074		
C Total	78	0.07230			

Root MSE	0.02728	R-square	0.2073
Dep Mean	0.17178	Adj R-sq	0.1970
C.V.	15.88112		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	0.147489	0.00622349	23.699	0.0001
MILES	1	0.009369	0.00208769	4.488	0.0001

MODEL=C FUEL=HT3

Model: MODEL1
Dependent Variable: HC HC Composite Emissions (g/mi)

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	1	0.04346	0.04346	35.752	0.0001
Error	89	0.10819	0.00122		
C Total	90	0.15165			

Root MSE	0.03487	R-square	0.2866
Dep Mean	0.21268	Adj R-sq	0.2786
C.V.	16.39335		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	0.171932	0.00773321	22.233	0.0001
MILES	1	0.015158	0.00253506	5.979	0.0001

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Ethyl Corporation HiTEC 3000 Fleet Testing Program
0-50k Data Analyzed
Data Set ETHYL3S2

-------------------------- MODEL=D FUEL=EEE --------------------------

Model: MODEL1
Dependent Variable: HC HC Composite Emissions (g/mi)

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	1	0.70205	0.70205	283.442	0.0001
Error	47	0.11641	0.00248		
C Total	48	0.81846			

Root MSE	0.04977	R-square	0.8578
Dep Mean	0.47904	Adj R-sq	0.8547
C.V.	10.38913		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	0.273535	0.01412613	19.364	0.0001
MILES	1	0.078001	0.00463305	16.836	0.0001

-------------------------- MODEL=D FUEL=HT3 --------------------------

Model: MODEL1
Dependent Variable: HC HC Composite Emissions (g/mi)

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	1	1.47694	1.47694	328.786	0.0001
Error	78	0.35038	0.00449		
C Total	79	1.82732			

Root MSE	0.06702	R-square	0.8083
Dep Mean	0.53698	Adj R-sq	0.8058
C.V.	12.48161		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	0.292797	0.01541084	18.999	0.0001
MILES	1	0.088888	0.00490215	18.132	0.0001

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---------------------------- MODEL=E FUEL=EEE ----------------------------

Model: MODEL1
Dependent Variable: HC HC Composite Emissions (g/mi)

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	1	0.07772	0.07772	65.937	0.0001
Error	72	0.08487	0.00118		
C Total	73	0.16258			

Root MSE	0.03433	R-square	0.4780
Dep Mean	0.16747	Adj R-sq	0.4708
C.V.	20.50002		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	0.111807	0.00793241	14.095	0.0001
MILES	1	0.021525	0.00265085	8.120	0.0001

---------------------------- MODEL=E FUEL=HT3 ----------------------------

Model: MODEL1
Dependent Variable: HC HC Composite Emissions (g/mi)

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	1	0.02985	0.02985	37.914	0.0001
Error	72	0.05668	0.00079		
C Total	73	0.08653			

Root MSE	0.02806	R-square	0.3449
Dep Mean	0.18593	Adj R-sq	0.3358
C.V.	15.09081		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	0.151548	0.00646699	23.434	0.0001
MILES	1	0.013199	0.00214358	6.157	0.0001

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MODEL=F FUEL=EEE

Model: MODEL1
Dependent Variable: HC HC Composite Emissions (g/mi)

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	1	2.24448	2.24448	508.126	0.0001
Error	78	0.34454	0.00442		
C Total	79	2.58902			

Root MSE	0.06646	R-square	0.8669
Dep Mean	0.48995	Adj R-sq	0.8652
C.V.	13.56501		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	0.201468	0.01479855	13.614	0.0001
MILES	1	0.107877	0.00478566	22.542	0.0001

MODEL=F FUEL=HT3

Model: MODEL1
Dependent Variable: HC HC Composite Emissions (g/mi)

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	1	1.65025	1.65025	505.465	0.0001
Error	76	0.24813	0.00326		
C Total	77	1.89838			

Root MSE	0.05714	R-square	0.8693
Dep Mean	0.48408	Adj R-sq	0.8676
C.V.	11.80363		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	0.232182	0.01293779	17.946	0.0001
MILES	1	0.094772	0.00421536	22.483	0.0001

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Data Set ETHYL3S2

---------------------------- MODEL=G FUEL=EEE ----------------------------

Model: MODEL1
Dependent Variable: HC HC Composite Emissions (g/mi)

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	1	0.00926	0.00926	19.855	0.0001
Error	72	0.03358	0.00047		
C Total	73	0.04284			

Root MSE	0.02160	R-square	0.2162
Dep Mean	0.12922	Adj R-sq	0.2053
C.V.	16.71279		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	0.110422	0.00490848	22.496	0.0001
MILES	1	0.007385	0.00165725	4.456	0.0001

---------------------------- MODEL=G FUEL=HT3 ----------------------------

Model: MODEL1
Dependent Variable: HC HC Composite Emissions (g/mi)

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	1	0.02972	0.02972	43.296	0.0001
Error	70	0.04804	0.00069		
C Total	71	0.07776			

Root MSE	0.02620	R-square	0.3822
Dep Mean	0.15651	Adj R-sq	0.3733
C.V.	16.73832		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	0.122096	0.00607391	20.102	0.0001
MILES	1	0.013477	0.00204823	6.580	0.0001

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Data Set ETHYL3S2

---------------------------- MODEL=H FUEL=EEE ----------------------------

Model: MODEL1
Dependent Variable: HC HC Composite Emissions (g/mi)

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	1	0.17690	0.17690	171.776	0.0001
Error	80	0.08238	0.00103		
C Total	81	0.25928			

Root MSE	0.03209	R-square	0.6823
Dep Mean	0.27287	Adj R-sq	0.6783
C.V.	11.76060		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	0.188530	0.00734603	25.664	0.0001
MILES	1	0.031865	0.00243129	13.106	0.0001

---------------------------- MODEL=H FUEL=HT3 ----------------------------

Model: MODEL1
Dependent Variable: HC HC Composite Emissions (g/mi)

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	1	0.21431	0.21431	115.613	0.0001
Error	82	0.15200	0.00185		
C Total	83	0.36631			

Root MSE	0.04305	R-square	0.5850
Dep Mean	0.27471	Adj R-sq	0.5800
C.V.	15.67235		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	0.183328	0.00971104	18.878	0.0001
MILES	1	0.033687	0.00313302	10.752	0.0001

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---------------------------- MODEL=I FUEL=EEE ----------------------------

Model: MODEL1
Dependent Variable: HC HC Composite Emissions (g/mi)

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	1	0.00091	0.00091	1.228	0.2714
Error	75	0.05571	0.00074		
C Total	76	0.05662			

Root MSE	0.02725	R-square	0.0161
Dep Mean	0.18299	Adj R-sq	0.0030
C.V.	14.89402		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	0.176982	0.00624672	28.332	0.0001
MILES	1	0.002314	0.00208792	1.108	0.2714

---------------------------- MODEL=I FUEL=HT3 ----------------------------

Model: MODEL1
Dependent Variable: HC HC Composite Emissions (g/mi)

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	1	0.00406	0.00406	6.202	0.0148
Error	82	0.05367	0.00065		
C Total	83	0.05773			

Root MSE	0.02558	R-square	0.0703
Dep Mean	0.19239	Adj R-sq	0.0590
C.V.	13.29739		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	0.179972	0.00571557	31.488	0.0001
MILES	1	0.004681	0.00187990	2.490	0.0148

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Data Set ETHYL3S2

---------------------------- MODEL=T FUEL=EEE ----------------------------

Model: MODEL1
Dependent Variable: HC HC Composite Emissions (g/mi)

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	1	0.42054	0.42054	360.511	0.0001
Error	75	0.08749	0.00117		
C Total	76	0.50803			

Root MSE	0.03415	R-square	0.8278
Dep Mean	0.31429	Adj R-sq	0.8255
C.V.	10.86729		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	0.188985	0.00766158	24.667	0.0001
MILES	1	0.047937	0.00252472	18.987	0.0001

---------------------------- MODEL=T FUEL=HT3 ----------------------------

Model: MODEL1
Dependent Variable: HC HC Composite Emissions (g/mi)

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	1	0.44387	0.44387	380.427	0.0001
Error	77	0.08984	0.00117		
C Total	78	0.53372			

Root MSE	0.03416	R-square	0.8317
Dep Mean	0.35053	Adj R-sq	0.8295
C.V.	9.74467		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	0.224651	0.00751148	29.908	0.0001
MILES	1	0.049014	0.00251293	19.505	0.0001

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ATTACHMENT 5

Ethyl Corporation HiTEC 3000 Fleet Testing Program
0-75k Data Analyzed

Fitted Regression Lines
Data Set ETHYL4S2
Pollutant Hydrocarbons

Model	Fuel	0 Miles (g/mi)	50k Miles (g/mi)	75k Miles (g/mi)	Deterioration Rate(a) (rate/10,000 mi)
D	HT3	0.3785	0.6227	0.7449	0.0489
	EEE	0.3167	0.6139	0.7625	0.0594
E	HT3	0.1518	0.2179	0.2510	0.0132
	EEE	0.1149	0.2157	0.2662	0.0202
F	HT3	0.3113	0.5877	0.7259	0.0553
	EEE	0.3174	0.5715	0.6985	0.0508
T	HT3	0.2755	0.3968	0.4575	0.0243
	EEE	0.2237	0.3740	0.4491	0.0301
C	HT3	0.1847	0.2237	0.2432	0.0078
	EEE	0.1517	0.1858	0.2029	0.0068
G	HT3	0.1313	0.1742	0.1956	0.0086
	EEE	0.1136	0.1407	0.1542	0.0054
H	HT3	0.1751	0.3710	0.4689	0.0392
	EEE	0.1904	0.3515	0.4320	0.0322
I	HT3	0.1796	0.1997	0.2097	0.0040
	EEE	0.1774	0.1881	0.1935	0.0022
Wtd Ave (b)	HT3	0.2091	0.3354	0.3986	0.0253
	EEE	0.1958	0.3164	0.3767	0.0241

Notes:

a. The deterioration rate is the rate of increase per 10,000 miles (slope of the regression line).

b. The weights for the weighted averages are proportional to 1988 sales figures.

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Ethyl Corporation HiTEC 3000 Fleet Testing Program
0-75k Data Analyzed
Data Set ETHYL4S2

---------------------------- MODEL=C FUEL=EEE ----------------------------

Model: MODEL1
Dependent Variable: HC HC Composite Emissions (g/mi)

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	1	0.02514	0.02514	36.495	0.0001
Error	106	0.07301	0.00069		
C Total	107	0.09814			

Root MSE	0.02624	R-square	0.2561
Dep Mean	0.17794	Adj R-sq	0.2491
C.V.	14.74913		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	0.151689	0.00502515	30.186	0.0001
MILES	1	0.006831	0.00113080	6.041	0.0001

---------------------------- MODEL=C FUEL=HT3 ----------------------------

Model: MODEL1
Dependent Variable: HC HC Composite Emissions (g/mi)

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	1	0.03287	0.03287	24.185	0.0001
Error	108	0.14676	0.00136		
C Total	109	0.17963			

Root MSE	0.03686	R-square	0.1830
Dep Mean	0.21455	Adj R-sq	0.1754
C.V.	17.18144		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	0.184741	0.00700752	26.363	0.0001
MILES	1	0.007797	0.00158536	4.918	0.0001

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Ethyl Corporation HiTEC 3000 Fleet Testing Program
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Data Set ETHYL4S2

---------------------------- MODEL=D FUEL=EEE ----------------------------

Model: MODEL1
Dependent Variable: HC HC Composite Emissions (g/mi)

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	1	1.25892	1.25892	187.801	0.0001
Error	70	0.46924	0.00670		
C Total	71	1.72816			

Root MSE	0.08187	R-square	0.7285
Dep Mean	0.54672	Adj R-sq	0.7246
C.V.	14.97555		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	0.316715	0.01935984	16.359	0.0001
MILES	1	0.059441	0.00433747	13.704	0.0001

---------------------------- MODEL=D FUEL=HT3 ----------------------------

Model: MODEL1
Dependent Variable: HC HC Composite Emissions (g/mi)

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	1	1.27689	1.27689	121.032	0.0001
Error	106	1.11830	0.01055		
C Total	107	2.39518			

Root MSE	0.10271	R-square	0.5331
Dep Mean	0.56744	Adj R-sq	0.5287
C.V.	18.10099		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	0.378459	0.01981860	19.096	0.0001
MILES	1	0.048855	0.00444073	11.001	0.0001

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Data Set ETHYL4S2

---------------------------- MODEL=E FUEL=EEE ----------------------------

Model: MODEL1
Dependent Variable: HC   HC Composite Emissions (g/mi)

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	1	0.21924	0.21924	67.987	0.0001
Error	106	0.34182	0.00322		
C Total	107	0.56105			

Root MSE	0.05679	R-square	0.3908
Dep Mean	0.19240	Adj R-sq	0.3850
C.V.	29.51500		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	0.114897	0.01087218	10.568	0.0001
MILES	1	0.020169	0.00244609	8.245	0.0001

---------------------------- MODEL=E FUEL=HT3 ----------------------------

Model: MODEL1
Dependent Variable: HC   HC Composite Emissions (g/mi)

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	1	0.09414	0.09414	105.901	0.0001
Error	106	0.09422	0.00089		
C Total	107	0.18836			

Root MSE	0.02981	R-square	0.4998
Dep Mean	0.20256	Adj R-sq	0.4950
C.V.	14.71845		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	0.151774	0.00570876	26.586	0.0001
MILES	1	0.013224	0.00128506	10.291	0.0001

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---------------------------- MODEL=F FUEL=EEE ----------------------------

Model: MODEL1
Dependent Variable: HC   HC Composite Emissions (g/mi)

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	1	1.26397	1.26397	97.534	0.0001
Error	102	1.32184	0.01296		
C Total	103	2.58581			

Root MSE	0.11384	R-square	0.4888
Dep Mean	0.50588	Adj R-sq	0.4838
C.V.	22.50287		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	0.317399	0.02211012	14.355	0.0001
MILES	1	0.050815	0.00514536	9.876	0.0001

---------------------------- MODEL=F FUEL=HT3 ----------------------------

Model: MODEL1
Dependent Variable: HC   HC Composite Emissions (g/mi)

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	1	1.49715	1.49715	178.470	0.0001
Error	102	0.85566	0.00839		
C Total	103	2.35281			

Root MSE	0.09159	R-square	0.6363
Dep Mean	0.51639	Adj R-sq	0.6328
C.V.	17.73654		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	0.311346	0.01778332	17.508	0.0001
MILES	1	0.055280	0.00413793	13.359	0.0001

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Data Set ETHYL4S2

---------------------------- MODEL=G FUEL=EEE ----------------------------

Model: MODEL1
Dependent Variable: HC   HC Composite Emissions (g/mi)

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	1	0.01592	0.01592	39.624	0.0001
Error	108	0.04340	0.00040		
C Total	109	0.05932			

Root MSE	0.02005	R-square	0.2684
Dep Mean	0.13457	Adj R-sq	0.2616
C.V.	14.89597		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	0.113621	0.00383821	29.603	0.0001
MILES	1	0.005407	0.00085895	6.295	0.0001

---------------------------- MODEL=G FUEL=HT3 ----------------------------

Model: MODEL1
Dependent Variable: HC   HC Composite Emissions (g/mi)

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	1	0.03965	0.03965	50.782	0.0001
Error	106	0.08277	0.00078		
C Total	107	0.12243			

Root MSE	0.02794	R-square	0.3239
Dep Mean	0.16427	Adj R-sq	0.3175
C.V.	17.01115		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	0.131300	0.00535106	24.537	0.0001
MILES	1	0.008579	0.00120392	7.126	0.0001

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Data Set ETHYL4S2

------------------------- MODEL=H FUEL=EEE -------------------------

Model: MODEL1

Dependent Variable: HC HC Composite Emissions (g/mi)

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	1	0.55864	0.55864	318.696	0.0001
Error	108	0.18931	0.00175		
C Total	109	0.74796			

Root MSE	0.04187	R-square	0.7469
Dep Mean	0.31413	Adj R-sq	0.7445
C.V.	13.32825		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	0.190431	0.00799662	23.814	0.0001
MILES	1	0.032206	0.00180404	17.852	0.0001

------------------------- MODEL=H FUEL=HT3 -------------------------

Model: MODEL1

Dependent Variable: HC HC Composite Emissions (g/mi)

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	1	0.82624	0.82624	218.288	0.0001
Error	108	0.40879	0.00379		
C Total	109	1.23503			

Root MSE	0.06152	R-square	0.6690
Dep Mean	0.32511	Adj R-sq	0.6659
C.V.	18.92385		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	0.175120	0.01172476	14.936	0.0001
MILES	1	0.039174	0.00265141	14.775	0.0001

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------------------------- MODEL=I FUEL=EEE -------------------------

Model: MODEL1

Dependent Variable: HC   HC Composite Emissions (g/mi)

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	1	0.00259	0.00259	3.866	0.0518
Error	108	0.07248	0.00067		
C Total	109	0.07508			

Root MSE	0.02591	R-square	0.0346
Dep Mean	0.18576	Adj R-sq	0.0256
C.V.	13.94569		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	0.177362	0.00493565	35.935	0.0001
MILES	1	0.002154	0.00109528	1.966	0.0518

------------------------- MODEL=I FUEL=HT3 -------------------------

Model: MODEL1

Dependent Variable: HC   HC Composite Emissions (g/mi)

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	1	0.00867	0.00867	14.916	0.0002
Error	108	0.06279	0.00058		
C Total	109	0.07146			

Root MSE	0.02411	R-square	0.1214
Dep Mean	0.19513	Adj R-sq	0.1132
C.V.	12.35726		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	0.179552	0.00464219	38.678	0.0001
MILES	1	0.004025	0.00104207	3.862	0.0002

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MODEL=T FUEL=EEE

Model: MODEL1
Dependent Variable: HC HC Composite Emissions (g/mi)

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	1	0.51034	0.51034	217.625	0.0001
Error	112	0.26265	0.00235		
C Total	113	0.77299			

Root MSE	0.04843	R-square	0.6602
Dep Mean	0.34261	Adj R-sq	0.6572
C.V.	14.13460		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	0.223746	0.00924596	24.199	0.0001
MILES	1	0.030051	0.00203710	14.752	0.0001

MODEL=T FUEL=HT3

Model: MODEL1
Dependent Variable: HC HC Composite Emissions (g/mi)

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	1	0.33239	0.33239	125.077	0.0001
Error	112	0.29764	0.00266		
C Total	113	0.63002			

Root MSE	0.05155	R-square	0.5276
Dep Mean	0.37148	Adj R-sq	0.5234
C.V.	13.87698		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	0.275513	0.00984619	27.982	0.0001
MILES	1	0.024264	0.00216961	11.184	0.0001

ATTACHMENT 6

Ethyl Corporation HiTEC 3000 Fleet Testing Program
0-75k Data Analyzed

Fitted Regression Lines
Data Set ETHYL3S2
Pollutant Hydrocarbons

Model	Fuel	0 Miles (g/mi)	50k Miles (g/mi)	75k Miles (g/mi)	Deterioration Rate(a) (rate/10,000 mi)
D	HT3	0.3809	0.6264	0.7491	0.0491
	EEE	0.3172	0.6151	0.7640	0.0596
E	HT3	0.1518	0.2178	0.2507	0.0132
	EEE	0.1152	0.2164	0.2670	0.0202
F	HT3	0.3160	0.5871	0.7226	0.0542
	EEE	0.3197	0.5761	0.7043	0.0513
T	HT3	0.2733	0.3992	0.4621	0.0252
	EEE	0.2236	0.3759	0.4520	0.0305
C	HT3	0.1889	0.2233	0.2405	0.0069
	EEE	0.1532	0.1857	0.2020	0.0065
G	HT3	0.1320	0.1713	0.1910	0.0079
	EEE	0.1126	0.1420	0.1568	0.0059
H	HT3	0.1750	0.3700	0.4674	0.0390
	EEE	0.1905	0.3521	0.4329	0.0323
I	HT3	0.1816	0.1998	0.2089	0.0036
	EEE	0.1769	0.1879	0.1934	0.0022
Wtd Ave (b)	HT3	0.2103	0.3352	0.3977	0.0250
	EEE	0.1962	0.3176	0.3783	0.0243

Notes:
a. The deterioration rate is the rate of increase per 10,000 miles (slope of the regression line).
b. The weights for the weighted averages are proportional to 1988 sales figures.

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Ethyl Corporation HiTEC 3000 Fleet Testing Program 1
0-75k Data Analyzed
Data Set ETHYL3S2

------------------------- MODEL=C FUEL=EEE -------------------------

Model: MODEL1
Dependent Variable: HC HC Composite Emissions (g/mi)

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	1	0.02322	0.02322	32.035	0.0001
Error	113	0.08191	0.00072		
C Total	114	0.10514			

Root MSE	0.02692	R-square	0.2209
Dep Mean	0.17787	Adj R-sq	0.2140
C.V.	15.13702		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	0.153216	0.00502760	30.475	0.0001
MILES	1	0.006503	0.00114890	5.660	0.0001

------------------------- MODEL=C FUEL=HT3 -------------------------

Model: MODEL1
Dependent Variable: HC HC Composite Emissions (g/mi)

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	1	0.02770	0.02770	20.674	0.0001
Error	129	0.17286	0.00134		
C Total	130	0.20057			

Root MSE	0.03661	R-square	0.1381
Dep Mean	0.21515	Adj R-sq	0.1314
C.V.	17.01419		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	0.188897	0.00660093	28.617	0.0001
MILES	1	0.006882	0.00151348	4.547	0.0001

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Ethyl Corporation HiTEC 3000 Fleet Testing Program
0-75k Data Analyzed
Data Set ETHYL3S2

------------------------------ MODEL=D FUEL=EEE ------------------------------

Model: MODEL1
Dependent Variable: HC HC Composite Emissions (g/mi)

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	1	1.26584	1.26584	189.399	0.0001
Error	71	0.47453	0.00668		
C Total	72	1.74037			

Root MSE	0.08175	R-square	0.7273
Dep Mean	0.54825	Adj R-sq	0.7235
C.V.	14.91164		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	0.317216	0.01932276	16.417	0.0001
MILES	1	0.059571	0.00432855	13.762	0.0001

------------------------------ MODEL=D FUEL=HT3 ------------------------------

Model: MODEL1
Dependent Variable: HC HC Composite Emissions (g/mi)

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	1	1.29648	1.29648	128.056	0.0001
Error	114	1.15417	0.01012		
C Total	115	2.45064			

Root MSE	0.10062	R-square	0.5290
Dep Mean	0.57172	Adj R-sq	0.5249
C.V.	17.59930		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	0.380907	0.01927734	19.759	0.0001
MILES	1	0.049097	0.00433869	11.316	0.0001

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------------------------------ MODEL=E FUEL=EEE ------------------------------

Model: MODEL1
Dependent Variable: HC HC Composite Emissions (g/mi)

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	1	0.22134	0.22134	69.210	0.0001
Error	108	0.34540	0.00320		
C Total	109	0.56675			

Root MSE	0.05655	R-square	0.3906
Dep Mean	0.19291	Adj R-sq	0.3849
C.V.	29.31548		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	0.115151	0.01079058	10.671	0.0001
MILES	1	0.020244	0.00243342	8.319	0.0001

------------------------------ MODEL=E FUEL=HT3 ------------------------------

Model: MODEL1
Dependent Variable: HC HC Composite Emissions (g/mi)

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	1	0.09383	0.09383	107.051	0.0001
Error	108	0.09467	0.00088		
C Total	109	0.18850			

Root MSE	0.02961	R-square	0.4978
Dep Mean	0.20264	Adj R-sq	0.4931
C.V.	14.61063		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	0.151832	0.00566387	26.807	0.0001
MILES	1	0.013187	0.00127449	10.347	0.0001

Ethyl Corporation HiTEC 3000 Fleet Testing Program
0-75k Data Analyzed
Data Set ETHYL3S2

---------------------------- MODEL=F FUEL=EEE ----------------------------

Model: MODEL1
Dependent Variable: HC   HC Composite Emissions (g/mi)

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	1	1.38965	1.38965	102.605	0.0001
Error	113	1.53044	0.01354		
C Total	114	2.92009			

Root MSE	0.11638	R-square	0.4759
Dep Mean	0.51357	Adj R-sq	0.4713
C.V.	22.66069		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	0.319678	0.02200336	14.529	0.0001
MILES	1	0.051288	0.00506327	10.129	0.0001

---------------------------- MODEL=F FUEL=HT3 ----------------------------

Model: MODEL1
Dependent Variable: HC   HC Composite Emissions (g/mi)

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	1	1.56082	1.56082	191.987	0.0001
Error	111	0.90241	0.00813		
C Total	112	2.46323			

Root MSE	0.09017	R-square	0.6336
Dep Mean	0.52245	Adj R-sq	0.6303
C.V.	17.25816		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	0.316044	0.01714225	18.437	0.0001
MILES	1	0.054210	0.00391237	13.856	0.0001

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Ethyl Corporation HiTEC 3000 Fleet Testing Program

0-75k Data Analyzed
Data Set ETHYL3S2

------------------------- MODEL=G FUEL=EEE -------------------------

Model: MODEL1
Dependent Variable: HC   HC Composite Emissions (g/mi)

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	1	0.02049	0.02049	40.294	0.0001
Error	117	0.05950	0.00051		
C Total	118	0.08000			

Root MSE	0.02255	R-square	0.2562
Dep Mean	0.13603	Adj R-sq	0.2498
C.V.	16.57818		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	0.112599	0.00423117	26.612	0.0001
MILES	1	0.005889	0.00092767	6.348	0.0001

------------------------- MODEL=G FUEL=HT3 -------------------------

Model: MODEL1
Dependent Variable: HC   HC Composite Emissions (g/mi)

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	1	0.03524	0.03524	39.926	0.0001
Error	114	0.10061	0.00088		
C Total	115	0.13585			

Root MSE	0.02971	R-square	0.2594
Dep Mean	0.16328	Adj R-sq	0.2529
C.V.	18.19464		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	0.131960	0.00567191	23.265	0.0001
MILES	1	0.007868	0.00124519	6.319	0.0001

--------------------------- MODEL=H FUEL=EEE ---------------------------

Model: MODEL1
Dependent Variable: HC HC Composite Emissions (g/mi)

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	1	0.60201	0.60201	323.240	0.0001
Error	123	0.22908	0.00186		
C Total	124	0.83109			

Root MSE	0.04316	R-square	0.7244
Dep Mean	0.31683	Adj R-sq	0.7221
C.V.	13.62105		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	0.190504	0.00801691	23.763	0.0001
MILES	1	0.032316	0.00179742	17.979	0.0001

--------------------------- MODEL=H FUEL=HT3 ---------------------------

Model: MODEL1
Dependent Variable: HC HC Composite Emissions (g/mi)

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	1	0.84951	0.84951	232.744	0.0001
Error	121	0.44165	0.00365		
C Total	122	1.29116			

Root MSE	0.06042	R-square	0.6579
Dep Mean	0.32568	Adj R-sq	0.6551
C.V.	18.55026		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	0.175032	0.01127777	15.520	0.0001
MILES	1	0.038987	0.00255550	15.256	0.0001

Ethyl Corporation HiTEC 3000 Fleet Testing Program
0-75k Data Analyzed
Data Set ETHYL3S2

MODEL=I FUEL=EEE

Model: MODEL1
Dependent Variable: HC HC Composite Emissions (g/mi)

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	1	0.00272	0.00272	4.224	0.0422
Error	113	0.07275	0.00064		
C Total	114	0.07547			

Root MSE	0.02537	R-square	0.0360
Dep Mean	0.18541	Adj R-sq	0.0275
C.V.	13.68529		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	0.176927	0.00475705	37.193	0.0001
MILES	1	0.002191	0.00106602	2.055	0.0422

MODEL=I FUEL=HT3

Model: MODEL1
Dependent Variable: HC HC Composite Emissions (g/mi)

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	1	0.00742	0.00742	12.560	0.0006
Error	118	0.06975	0.00059		
C Total	119	0.07717			

Root MSE	0.02431	R-square	0.0962
Dep Mean	0.19538	Adj R-sq	0.0885
C.V.	12.44321		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	0.181597	0.00447860	40.548	0.0001
MILES	1	0.003644	0.00102820	3.544	0.0006

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Ethyl Corporation HiTEC 3000 Fleet Testing Program
0-75k Data Analyzed
Data Set ETHYL3S2

---------------------------- MODEL=T FUEL=EEE ----------------------------

Model: MODEL1
Dependent Variable: HC HC Composite Emissions (g/mi)

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	1	0.53949	0.53949	226.419	0.0001
Error	117	0.27878	0.00238		
C Total	118	0.81827			

Root MSE	0.04881	R-square	0.6593
Dep Mean	0.34347	Adj R-sq	0.6564
C.V.	14.21172		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	0.223569	0.00913880	24.464	0.0001
MILES	1	0.030460	0.00202427	15.047	0.0001

---------------------------- MODEL=T FUEL=HT3 ----------------------------

Model: MODEL1
Dependent Variable: HC HC Composite Emissions (g/mi)

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	1	0.37764	0.37764	136.452	0.0001
Error	119	0.32934	0.00277		
C Total	120	0.70697			

Root MSE	0.05261	R-square	0.5342
Dep Mean	0.37109	Adj R-sq	0.5302
C.V.	14.17641		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	0.273316	0.00964020	28.352	0.0001
MILES	1	0.025170	0.00215470	11.681	0.0001

Systems Applications
November 4, 1991

Systems Applications International

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415-507-7100 Facsimile 415-507-7177
A Division of Clement International Corporation
Environmental and Health Sciences

MEMORANDUM

TO: Ethyl Corporation

FROM: Alison Pollack and Jonathan Cohen

SUBJECT: Further analysis of Ethyl fleet testing data

DATE: 17 October 1991

Reference: SAI memo dated 2 October 1991

In the referenced memorandum we responded to Ford Motor Company's ("Ford") comments on the generation of the data sets used in Systems Applications International's ("SAI") statistical analysis of the emissions data from Ethyl Corporation's ("Ethyl") 48-car test program. In particular, we categorically disagreed with the suggestion by Ford that SAI "subjectively" created a subset of data for statistical analysis that would generate statistical results favorable to Ethyl, and noted that we had applied the statistical analyses to the data set which, in our view, complied with all applicable regulatory requirements regarding the certification of vehicles under the Clean Air Act and which provided the most "objective" view of the emission test results. We also stated our belief that the conclusions to be drawn from Ethyl's 48-car test program would not change if the statistical tests were repeated using the data not included in SAI's reported analyses. Since then, we have repeated the statistical analyses on a data set containing previously excluded data, and found no difference in the results. These additional analyses were briefly described at our meeting with the Environmental Protection Agency's Office of Mobile Sources on 15 October 1991. The purpose of this memorandum is to document these additional analyses.

For the record, we again repeat the data sets that were generated, the tests that were excluded in each, and the reasons for exclusion of tests:

ETHYL0S — Data as received from the test laboratories. No tests were excluded, except one test for the replacement vehicle designated D3A: the single test of D3A at 15,554 miles (initial mileage upon receipt). All tests of the replacement vehicle with the old vehicle's emission control system (labeled as D3A) are included.

ETHYL1S — 164 zero-mile tests were excluded, per 40 CFR 86.088-28.

akp9274

ETHYL2S	136 tests that were invalid from an engineering point of view and therefore considered to be "justifiable drops" were excluded.
ETHYL3S	339 tests preceding unscheduled maintenance were excluded per 40 CFR 86.088-28.
ETHYL4S	151 tests which were "extra" tests beyond the standard two were deleted.
ETHYL4S2	102 tests at 50,000 miles after the first two tests before component changes were deleted.

The analyses originally performed by Systems Applications, and incorporated as Appendix 2A to Ethyl's waiver application of 9 May 1990, are based on data set ETHYL4S2, which we believed to be, and still believe to be, that data set which is statistically the most sound, in the sense of having the least potential for biased results.

We repeated all of the adverse effects tests and the Cause or Contribute test on data set ETHYL1S. That is, we included in these new analyses all "extra" tests, all tests preceding unscheduled maintenance, and all tests considered invalid from an engineering point of view. Although there were small changes in some of the numerical quantities estimated (as would, of course, be expected), the conclusions drawn from the 50,000 mile and 75,000 mile analysis of the data set ETHYL1S are identical to those from the data set ETHYL4S2 as described in Appendix 2A to the waiver application. All of the tabulated results, in the same format as presented in Appendix 2A, are available; they are not included here because of their large volume and because the conclusions do not change. Please note that these analyses were performed only to attempt to put to rest Ford's implication that inclusion of previously excluded tests would change the interpretation of Ethyl's data; we still stand behind our original analyses of data set ETHYL4S2.

CLEMENT

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Environmental and Health Science

November 22, 1991

Dr. Don Lynam
Ethyl Building
451 Florida Blvd.
Baton Rouge, LA 70801

Subject: Net Risks from MMT Use and Reformulated Gasoline

Dear Don:

Regarding the net risk analysis for MMT use that I did in support of Ethyl's waiver application (the actual title of the submitted document is "Health and Environmental Risks and Benefits from Use of MMT in Unleaded Gasoline," revised June 20, 1991), and its applicability to reformulated gasoline: The emissions tests that provided the data on carcinogenic emissions did include some data on the effect of MMT when used with a reformulated gasoline. However, for reasons noted below and in the earlier analysis, while there are some data with which to make an assessment of the effect of MMT on emissions with reformulated gasoline, the limitations associated with the data and with such an analysis would make the results difficult to interpret, and probably of little value.

By contrast, it is possible to compute risks from carcinogenic air emissions from conventional commercial fuel, and to assess how these risks would be affected by MMT use. A revision of the June 20 assessment that looks at the effect of MMT use in commercial unleaded gasoline, based on the results from the speciation tests applied to an analysis by Adler and Carey of EPA Ann Arbor, has been made and is presented below. The difference between the June 20 net risk analysis and this current analysis is that the current analysis is based on the observed reduction in emissions associated with commercial fuel. The earlier analysis was based on the average reductions observed for three fuels (Howell EEE, commercial unleaded, and a reformulated gasoline). This more current analysis may therefore be more appropriate for evaluating risks where reformulated fuels are not used.

The limitations in the test data, noted in the June 20 report submitted to EPA, are as follows. The data comes from the speciation tests conducted by the Southwest Research

Institute (SWRI) for Ethyl. In these tests, MMT was added to the three fuels and emissions were measured with these fuels run through a Ford Crown Victoria. For comparison purposes, tests were run in a second Crown Victoria with the three fuels without MMT, but with xylenes added in order to provide a fuel of an equivalent octane to that used in the MMT tests. The results of the speciation measurements relevant to a risk assessment were the measured emission rates of four air toxics: benzene, formaldehyde, 1,3-butadiene, and acetaldehyde (these were the carcinogenic air toxics identified by Adler and Carey). Reductions were observed with MMT use for each of the four air toxics, for each of the three fuels.

Table 1 describes the risk estimates for carcinogenic emissions based on the Adler and Carey analysis. Tables 2 and 3 provide estimates of the risk reductions that would result from MMT use in commercial unleaded gasoline. The numbers in Tables 2 and 3 refer to lifetime individual risk of cancer, following the standard EPA method of calculation. Table 2 reflects average or typical exposures and risks. Table 3 calculates the exposures and risks that would be experienced if individuals were exposed to concentrations of automobile emissions so high that exposure to manganese at the RfC value would result. In the high exposure case, exposures are roughly 33 times those of the average case. As noted in the earlier analysis, the data from Toronto and the measured exposures of Los Angeles taxi drivers to lead suggest that such high exposures do not occur.

The population risk estimates are calculated, for the average population case, for an assumed 1995 U.S. population of 260 million. For a more specific estimate of the population risk reduction in commercial fuel areas, these numbers should be scaled to reflect actual populations and exposures in those areas. The population risk estimate for the high exposure case is expressed in units of cases per million population per year. It should be noted that the exposure assessment analyses for MMT projects that such high exposures will not occur, even for small population subgroups.

Summary and Results

Because it is not clear how MMT would be used in reformulated gasoline (i.e., how a reformulated gasoline based on MMT would differ from one without MMT), no risk reduction estimate has been provided regarding use of MMT in reformulated gasoline. It bears noting that one of the fuels tested by SWRI contained MTBE. This "reformulated" gasoline showed lower toxic emissions (by 7-12%) with MMT when compared to the equivalent octane counterpart.

This revised analysis indicates that the calculated risk reduction from MMT use is insensitive to whether the observed emission reductions from commercial fuel or the average reduction for the three fuels is used. While there are differences between these two analyses in terms of the reduction in exposure and risk associated with each specific chemical of concern, there is no difference when the total risk from the four air toxics is considered.

The June 20 report and this analysis both indicate that risks from carcinogenic automobile emissions would be reduced by about 18% with MMT use. In terms of individual risk, with MMT use the average individual's risk reduction is estimated to be 1.3×10^{-5}. Given that the 1990 Clean Air Act Amendments seek to avoid risks in excess of 10^{-6}, this seems to me to be a significant reduction in risk. The population risk estimate, a reduction of 49 cancer cases per year in a population of 260 million, provides a further indication of the significance of the potential risk reduction.

Sincerely,

Chris Whipple

Chris G. Whipple, Ph.D.
Vice President

cc: Kevin Fast, Hunton & Williams

Table 1 -- Risks from Carcinogens based on 1995 emission estimates from Adler & Carey 1989			
	Emissions, grams/mile	Individual Risk	Population Risk, Cases/yr/ 260 million
benzene	0.0575	2.16e-05	80.15
formaldehyde	0.01565	7.02e-06	26.07
1,3-butadiene	0.0045	4.20e-05	156.00
acetaldehyde	0.0045	3.41e-07	1.27
total		7.09e-05	263.50

Table 2 -- Cancer Risk Reduction with MMT -- Average Exposure Case				
	Risk with Commercial Unleaded	Risk with Commercial Unleaded with MMT	Individual Risk Reduction	Population Risk Reduction Cases/yr/260 million
benzene	2.16e-05	1.39e-05	7.72e-06	28.7
formaldehyde	7.02e-06	5.45e-06	1.57e-06	5.8
1,3-butadiene	4.20e-05	3.82e-05	3.82e-06	14.2
acetaldehyde	3.41e-07	2.70e-07	7.41e-08	0.3
total	7.09e-05	5.78e-05	1.32e-05	49.

Table 3 -- Cancer Risk Reduction with MMT -- High Exposure Case				
	Risk with Commercial Unleaded	Risk, Commercial Unleaded with MMT	Individual Risk Reduction	Population Risk Reduction Cases/yr/million
benzene	7.10e-04	4.56e-04	2.54e-04	3.63
formaldehyde	2.31e-04	1.79e-04	5.17e-05	0.74
1,3-butadiene	1.38e-03	1.26e-03	1.26e-04	1.80
acetaldehyde	1.12e-05	8.78e-06	2.44e-06	0.03
total	2.33e-03	1.90e-03	4.34e-04	6.20

Final Report

STATISTICAL ANALYSIS OF THE COMBINED ETHYL AND FORD FLEETS

22 November 1991

Prepared for

Ethyl Corporation
451 Florida Boulevard
Baton Rouge, LA 70801

Prepared by

Systems Applications International
101 Lucas Valley Road
San Rafael, California 94903

415-507-7100

EXECUTIVE SUMMARY

Ethyl Corporation has submitted a waiver application for the fuel additive HITEC 3000. The application includes a detailed statistical analysis of Ethyl's extensive emissions testing data (48 cars operated up to 75,000 miles each) using tests originally applied by the EPA and several enhancements of these procedures. The results of the tests designed to determine if the fuel additive would cause or contribute to the failure of an emissions control system to meet applicable standards were all passed.

In response to Ethyl's submission, Ford Motor Company provided testing data on a set of four 1991 Ford Escorts and four 1991 prototype Ford Explorer trucks. We have combined the Ford data with the Ethyl data and applied appropriately modified versions of the EPA and enhanced EPA statistical tests to the combined fleet data. The results are essentially the same for the combined fleet as they were for the Ethyl fleet. The only differences were for two adverse effects tests that were not part of the original EPA test procedures, and for some of the initial emissions tests, which do not measure adverse fuel additive effects. All cause or contribute tests were passed for the combined fleet.

INTRODUCTION

The details and results of the Ethyl fleet testing program appear in Ethyl's fuel waiver application which was submitted in May 1990. Appendix 2A of the May 1990 waiver application includes a detailed statistical data analysis prepared, on Ethyl's behalf, by Systems Applications International (SAI). SAI applied statistical tests developed by the EPA in response to Ethyl's previous 1978 waiver application for HiTEC 3000 (43 Fed. Reg. 41424).

In addition to applying these EPA tests to the Ethyl fleet data, SAI applied modified versions of these tests. In most cases the modifications included

1. The use of a more powerful parametric test in addition to the EPA non-parametric tests. The power of a test is the likelihood that the statistical test will detect an effect if such an effect exists. These tests were applied to the eight Ethyl model groups.

2. The use of tests based on quadratic regression in addition to EPA's linear regression tests.

3. Analysis of the 75,000 mile data in addition to analysis of the 50,000 mile data. (The Ethyl fleet was only certified to 50,000 miles.)

4. The use of parametric tests based on a weighted average of the emissions effects for the eight models. This weighted average was based on 1988 sales weights. The Ethyl fleet represented about 53 percent of actual 1988 light duty automobile sales.

Complete details of these EPA and SAI tests appear in Attachment C of Appendix 2A of the May 1990 waiver application. The results of the statistical tests applied to the Ethyl fleet are also provided in Appendix 2A of Ethyl's May 1990 waiver application.

In July 1991, Ethyl resubmitted the waiver application for HiTEC 3000. In October 1991, in response to Ethyl's submittal, Ford Motor Company (Ford) submitted to the Docket emissions data from a relatively small fleet consisting of four 1991 production Ford Escorts and four 1991 production Ford Explorers. The 1991 Ford Escorts are certified to 50,000 miles. The Ford Explorers were equipped with a 1993 production prototype engine. These vehicles are certified to 100,000 miles and are classified as light trucks, rather than light duty automobiles. The 50,000 mile federal emissions standards for the Ethyl fleet and for the Ford fleet Escorts are 0.41 g/mi of hydrocarbons, 3.4 g/mi of carbon monoxide, and 1.0 g/mi of nitrogen oxides. The 100,000 mile federal emissions standards for the Ford Explorer are 0.8 g/mi of hydrocarbon, 10 g/mi of carbon monoxide, and 1.7 g/mi of nitrogen oxides. The Ford fleet was tested up to 105,000 miles at approximately 30,000 mile intervals (the test intervals were 5,000 miles, 20,000 miles, 55,000 miles, 85,000 miles, and 105,000 miles.)

SAI was retained by Ethyl Corporation to perform an integrated analysis of the combined Ethyl fleet and Ford fleet data to re-examine the cause or contribute and adverse effects tests described in Appendix 2A of Ethyl's May 1990 waiver application.

In the following section "Methodology" we shall describe the modification of the Appendix 2A statistical tests to treat the combined Ethyl and Ford fleet data. In the section "Summary of results" we summarize the differences between the passed and failed statistical tests for the Ethyl fleet in appendix 2A of the May 1990 waiver application and the results for the analysis of the combined fleet. The appendix to this report contains tables of detailed results for all the statistical tests applied to the combined fleet in a format similar to those presented in Attachments C and D of appendix 2A.

METHODOLOGY

The Ethyl fleet was divided into eight model groups (D, E, F, T, C, G, H, and I). Each model group has six vehicles, three of which accumulated mileage on Howell EEE and three of which accumulated mileage on Howell EEE with HiTEC 3000 added. The model group D was an exception because one of the EEE vehicles in that group was deleted from the analysis due to modifications in the emission control system. Model group E contains the Ethyl fleet Ford Escort vehicles. The Ford fleet consists of two model groups: Four 1991 production year Ford Escorts assigned to model group A and Four 1991 production year Ford Explorers assigned to model group B.

To calculate weights for the combined fleet of ten model groups (the original eight Ethyl model groups together with two Ford model groups) we used a similar approach to that in Appendix 2A. Each vehicle model group was weighted according to the percentage of 1988 automobile and light duty truck sales. Then the weight for the Escort group was allocated equally to the Ethyl fleet Escorts (group E) and Ford fleet Escorts (group A). The weights are summarized in Table 1.

Table 1. Sales weights for the combined fleet.

Models	Percent Sales	Model group	Weight (%)
C	3.9	C	10.5
D	1.3	D	3.5
E/A	3.8	E	5.1
		A	5.1
F	4.9	F	13.1
G	2.9	G	7.8
H	8.8	H	23.6
I	6.4	I	17.2
T	4.5	T	12.1
B	0.8	B	2.1
Total	37.3		100.0

Thus the combined fleet represents about 37 percent of all 1988 automobile and light duty truck sales whereas the Ethyl fleet represented about 53 percent of 1988 automobile sales.

The data base used for analysis was the Ethyl data set ETHYL4S2 (used to calculate most of the results in Appendix 2A) combined with the Ford data, with some Ford measurements excluded as described below.

The raw Ford data set consisted of 217 emissions tests. For the analysis in this report we dropped 17 tests, as follows. Using the approach apparently adopted by Ford in their analyses dated September 6, 1991, we excluded the first three tests at 55,000 miles and the first four tests at 105,000 miles for Explorer 306. These tests should be excluded according to the Federal Regulations (40 CFR 86.088-28) because they were before unscheduled maintenance. For the Ford fleet Escort 318 (the Escort that had an accident at 10,106 miles and was then completely repaired), all ten emissions tests prior to the 15,000 mile odometer reading were dropped and 10,106 was subtracted from all odometer readings after 15,000 miles. The three emissions tests on Escort 318 at 10,600 miles were dropped because they correspond to zero miles emissions tests [40 CFR 86.088-28(a)(4)(i)(A)(1)]. This approach assumes (as Ford apparently has also assumed) that the completely repaired vehicle is the same as a new vehicle for the purpose of emissions testing.

Since the mileage groups for the Ford data were 5K, 20K, 55K, 85K and 105K, but the Ethyl fleet mileages were 1K, 5K, 10K, 15K, ... 75K, the set of statistical tests previously applied to the Ethyl fleet data were in many cases modified to deal with the combined fleet. In some cases a modified version was not appropriate and the corresponding test was omitted (for example, the change from 1K to 5K was not measured for the Ford Escort and Explorer data so the corresponding statistical test cannot be applied to the combined fleet.)

We shall now briefly describe the statistical tests that were applied to the Ethyl fleet and modified for the combined fleet. Due to differences in the testing protocols, a combined fleet version could not be developed for the tests of the change from 1,000 to 5,000 miles, the change from 1,000 to 75,000 miles, and for the integrated emissions from 1,000 to 75,000 miles. More details of these tests, and, in particular, of the differences between the equal and unequal car effects versions of some of these tests, appear in appendix 2A of the May 1990 waiver application.

50,000 mile tests

Note that for the following 50,000 mile analyses, linear and quadratic regression curves were fitted to the data up to 50,000 miles for Ethyl's fleet and to the data up to 55,000 miles for the Ford fleet. The violation mileage, maximum percentage failing standards, and cause or contribute tests extrapolated the fitted regression curves to 100,000 miles to treat the Ford Explorer data. (Regression predictions at 100,000 miles for the Explorers were used to determine violations of the 100,000 mile emissions standard, even though the Ford fleet was tested up to 105,000 miles). The 75,000 mile analyses did not require extrapolation of the fitted regression curves beyond the mileage ranges in the data.

<u>Initial emissions test</u>

This test compares initial emissions of the HITEC 3000 fleet with the initial emissions of the Clear fleet to determine if initial differences might mask a fuel effect. Since the initial emissions test is designed to be applied prior to the waiver fuel accumulation, this is not an adverse effects test. For the Ethyl fleet the analysis compared initial emissions at 1,000 miles. For the combined fleet, two alternative sets of analyses were made. In the first case, the initial mileages were the mileage intervals just before the HiTEC 3000 accumulation. For this version, the Ethyl fleet initial emissions were compared at 1,000 miles whereas the Ford fleet initial emissions were compared at 5,000 miles. The second version matched the initial mileages and compared the initial emissions levels at 5,000 miles for both fleets.

Change from 1K to 50K

This test compares the increases in emissions from 1,000 to 50,000 miles for the two fuels. The first modified version of this test for the combined fleet matched the mileage accumulation by comparing the fuel increases from 1,000 to 50,000 miles for the Ethyl fleet and from 5,000 to 55,000 miles for the Ford fleet. The alternative version matched mileages and compared the fuel increases in emissions from 5,000 to 55,000 miles for both fleets.

Integrated emissions from 1K to 50K

The integrated emissions tests use all the data collected between the starting and ending mileages, rather than only the data at the starting and ending mileages (as in the previous test). The total integrated emissions are defined as the total emissions (grams) above the level at the starting mileage. The total integrated emissions, estimated by numerical integration separately for each vehicle, divided by the accumulated mileage between the starting and ending mileages defines the integrated emissions above initial levels (grams per mile). The statistical test compares the average integrated emissions above initial levels (grams per mile) for the two fuels.

The Ethyl fleet version of this test compared the integrated emissions from 1,000 to 50,000 miles for the two fuels. The first modified version of this test for the combined fleet matched the mileage accumulation by comparing the fuel integrated emissions from 1,000 to 50,000 miles for the Ethyl fleet and from 5,000 to 55,000 miles for the Ford fleet. The alternative version matched mileages and compared the fuel integrated emissions from 5,000 to 55,000 miles for both fleets.

Linear regression slopes test

This test compares the slopes of a fitted linear regression line for the two fuels. The regression model for each model group assumes that the average emissions at a given mileage are related to the mileage by a straight line. The slope is also known as the deterioration rate. For the Ethyl fleet 50,000 mile analysis the regression lines were fitted to all the data up to and including 50,000 miles. For the combined analysis the Ethyl fleet data up to and including 50,000 miles was combined with the Ford data up to and including 55,000 miles.

Linear regression 50K/4K deterioration factors

This test compares the ratios of the predictions at 50,000 miles divided by the predictions at 4,000 miles. The predictions are based on a fitted linear regression line. For the Ethyl fleet 50,000 mile analysis the regression lines were fitted to all the data up to and including 50,000 miles. For the combined analysis the Ethyl fleet data up to and including 50,000 miles was combined with the Ford data up to and including 55,000 miles.

Linear regression violation mileage

This test compares the violation mileages for the two fuels. The violation mileage is defined as the mileage predicted by the linear regression line at which the emissions first reach the federal emissions standard. For the Ethyl fleet the vehicles were certified up to 50,000 miles and so the violation mileage was restricted to be between 0 and 50,000 miles (otherwise it was undefined). For the combined fleet the same analysis was applied except for the model group B (the Ford Explorers). Since that model group was certified to 100,000 miles and had different emissions standards, the violation mileage for the Explorer group was allowed to vary from 0 to 100,000 miles and the Explorer emissions standards for HC, CO, and NO_x were applied specially for that model group. For the Ethyl fleet 50,000 mile analysis the regression lines were fitted to all the data up to and including 50,000 miles. For the combined analysis the Ethyl fleet data up to and including 50,000 miles was combined with the Ford data up to and including 55,000 miles.

Linear regression maximum percentage failing standard

The maximum percentage failing the emissions standard is estimated from the regression line rather than from the percentages of actual emissions standard violations at the testing mileages. Using the regression model the estimated percentage of vehicles that would fail the applicable emissions standard at each mileage from 0 up to the certification mileage is calculated. The statistical test compares the maximum estimated failure rates for the two fuels. For the Ethyl fleet the vehicles were certified up to 50,000 miles and so the mileage range was restricted to be between 0 and 50,000 miles. For the combined fleet the same analysis was applied except for the model group B (the Ford Explorers). Since that model group was certified to 100,000 miles and had different emissions standards, the maximum estimated percentage of failures for that model group only was evaluated across all mileages from 0 to 100,000 miles using the Explorer emissions standards. For the Ethyl fleet 50,000 mile analysis the regression lines were fitted to all the data up to and including 50,000 miles. For the combined analysis the Ethyl fleet data up to and including 50,000 miles was combined with the Ford data up to and including 55,000 miles.

Quadratic regression 25,000 mile slope

This test compares the slopes at 25,000 miles of a fitted quadratic regression curve for the two fuels. The quadratic regression model for each model group assumes that the average emissions at a given mileage are given by a constant plus a multiple of the mileage plus another multiple of the squared mileage. The slope varies with mileage for a quadratic regression model. For the Ethyl fleet 50,000 mile analysis the regression curves were fitted to all the data up to and including 50,000 miles. For the combined analysis the Ethyl fleet data up to and including 50,000 miles was combined with the Ford data up to and including 55,000 miles.

Quadratic regression 50,000 mile slope

This test is similar to the quadratic regression 25,000 mile slope test, except that the slope at 50,000 miles is used instead of the slope at 25,000 miles.

Quadratic regression coefficient

This test uses the same quadratic regression curves calculated in the last two tests. The test compares the quadratic regression coefficients for the two fuels, which are multiples of the rate of increase of the deterioration rate. A negative quadratic coefficient means that the deterioration rate decreases with mileage. For the Ethyl fleet 50,000 mile analysis the regression curves were fitted to all the data up to and including 50,000 miles. For the combined analysis the Ethyl fleet data up to and including 50,000 miles was combined with the Ford data up to and including 55,000 miles.

Quadratic regression 50K/4K deterioration factors

This test is the same as the linear regression 50K/4K deterioration factors test except that the predictions at 4,000 miles and 50,000 miles are based on the quadratic regression curve rather than the linear regression line. For the Ethyl fleet 50,000 mile analysis the regression curves were fitted to all the data up to and including 50,000 miles. For the combined analysis the Ethyl fleet data up to and including 50,000 miles was combined with the Ford data up to and including 55,000 miles.

Quadratic regression violation mileage

This test and its modification for the combined fleet is the same as the 50,000 mile analysis linear regression violation mileage test, with the replacement of the fitted linear regresssion line with a fitted quadratic regression curve.

Quadratic regression maximum percentage failing standard

This test and its modification for the combined fleet is the same as the 50,000 mile analysis linear regression maximum percentage failing standard test, with the replacement of the fitted linear regression line with a fitted quadratic regression curve.

Linear regression cause or contribute test

This test is related to the maximum percentage failing standard test. At each mileage inside the applicable mileage range, the estimated percentage failure rate according to the linear regression predictions is compared between the clear and HiTEC 3000 fuels. The test is failed for a particular model group if at any mileage within the mileage range, the estimated HiTEC 3000 percentage failure rate exceeds both ten percent and the estimated clear fuel percentage failure rate. The overall cause or contribute test is based on the number of model groups that fail the cause or contribute test. For the 50,000 mile analysis the mileage range is 0 to 50,000 miles for the Ethyl fleet and for the Ford fleet Escorts, but is 0 to 100,000 miles for the Ford Explorer model group.

Quadratic regression cause or contribute test

This is the same as the last test except that quadratic regression curves are used instead of the linear regression lines.

75,000 mile tests

The title refers to the Appendix 2A analyses. All available data up to 75,000 miles for the Ethyl fleet and up to 105,000 miles for the Ford fleet were used for the following 75,000 mile combined analyses.

Integrated emissions from 5K to 75K

The Ethyl fleet analysis was based on the integrated emissions above initial emissions levels from 5,000 to 75,000 miles. For the combined fleet analysis, the same calculations were applied to the Ethyl fleet, but the integrated emissions above initial levels for the Ford fleet were evaluated from 5,000 to 105,000 miles. Although the mileage accumulations are different, these integrated emissions rates can be combined into the same analysis because they are both expressed in grams per mile and not in grams. Division by the accumulated mileage accounts for the fact that the total emissions in grams is greater over longer mileage intervals.

Quadratic regression slopes, coefficient, and deterioration factor tests

The 75,000 mile combined analyses of quadratic regression slopes and quadratic coefficients were similar to the 50,000 mile analyses except that all the Ethyl and Ford data were used to fit the quadratic regression curves. The 75,000 mile analysis of the deterioration factor was also similar to the 50,000 mile analysis except that the deterioration factor used was the ratio of the predictions at 75,000 and 4,000 miles.

Linear regression post 50K slope test

This test is similar to the 50,000 mile analysis linear regression slope test except that the linear regression was fitted to the data including and after 55,000 miles.

Quadratic regression violation mileage, maximum percentage failing standard, and cause or contribute tests

These tests are modified versions of the corresponding 50,000 mile quadratic regression tests except that the mileage range for possible violations of the automobile emissions standards was taken to be from 0 to 75,000 miles instead of from 0 to 50,000 miles. The mileage range for the Ford Explorer was, as in the 50,000 analysis, from 0 to 100,000 miles. The 75,000 mile analysis used all the Ethyl and Ford data.

SUMMARY OF RESULTS

The detailed results are in the tables and the Appendix. Tables 2a, 2b, and 2c (for hydrocarbons, nitrogen oxides, and carbon monoxide, respectively) summarize the passes and failures for the statistical tests. A test is deemed to be passed if the significance level is 5 percent or greater. The column headed "Data used" summarizes the data mileages or mileage ranges used in the analysis. The mileages before the slash refer to the Ford data and the mileages after the slash refer to the Ethyl data. The columns headed "EPA non-parametric" and "Weighted average" give the passes (P) and failures (F) for the initial emissions, adverse effects, and cause or contribute tests. The letters before the brackets give the results for the combined fleet analyses. The letters inside the brackets give the results in Appendix 2A for the Ethyl fleet analysis, if a corresponding analysis was performed. If in the column "EPA non-parametric" a pair of letters appears either inside or outside the brackets, then the first letter refers to the EPA sign test and the second letter refers to the EPA overall rank sum test. (In all cases these tests were either both failed or both passed.) If a single letter appears in that column either inside or outside the brackets, then only the EPA sign test was applied. The results in the column "Weighted average" refer to the passed and failed weighted average tests. These tests use the 1988 sales weights given in table 1 to weight the model groups.

In the remainder of this section we list the differences from tables 2a, 2b and 2c between the Ethyl fleet test results and the combined fleet test results. In summary it is clear that with very few exceptions the results for the Ethyl fleet and combined fleet are identical when only passes and failures are considered. The only adverse affects tests that gave different results for the combined fleet than for the Ethyl fleet were the SAI tests of the quadratic regression slopes at 25,000 miles for hydrocarbons. The cause or contribute tests were all passed. There were some differences for the initial emissions tests. There are

Table 2a. Summary of the Ethyl and Ford fleet statistical tests for hydrocarbons.

Description	Data used (Ford/ Ethyl)	EPA non-parametric All (Ethyl)	Weighted Average All (Ethyl)
<u>50K tests</u>			
Initial emissions	1K/5K		
equal car-means		PP(PP)	P(P)
unequal car-means		P(P)	P(P)
Initial emissions	5K/5K		
equal car-means		FF	F
unequal car-means		F	F
Change from 1K to 50K	5K,55K/		
equal car effects	1K,50K	PP(PP)	P(P)
unequal car effects		P(P)	P(P)
Change from 5K to 55K	5K,55K/		
equal car effects	5K,55K	PP	P
unequal car effects		P	P
Integrated emissions from 1K to 50K	5-55K/ 1-50K	FF(FF)	F(F)
Integrated emissions from 5K to 55K	5-55K/ 5-55K	PP	P
Linear regression slopes	5-55K/ 1-50K	P(P)	P(P)
Linear regression deterioration factors	5-55K/ 1-50K	P(P)	P(P)
Linear regression violation mileage <=50K (Expl <= 100K)	5-55K/ 1-50K	P(P)	
Linear regression max % failing standard before 50K (Expl 100K)	5-55K/ 1-50K	P(P)	
Quadratic regression 25,000 mile slope	5-55K/ 1-50K	P(P)	F(P)
Quadratic regression 50,000 mile slope	5-55K/ 1-50K	P(P)	P(P)
Quadratic regression coefficient	5-55K/ 1-50K	P(P)	P(P)
Quadratic regression 50K/4K deterioration factor	5-55K/ 1-50K	P(P)	P(P)

Table 2a. Concluded.

Description	Data used (Ford/ Ethyl)	EPA non-parametric All (Ethyl)	Weighted Average All (Ethyl)
Quadratic regression violation mileage <=50K (Expl 100K)	5-55K/ 1-50K	P(P)	
Quadratic regression max % failing standard before 50K (Expl 100K)	5-55K/ 1-50K	P(P)	
Linear regression cause or contribute before 50K (Expl 100K)	5-55K/ 1-50K	P(P)	
Quadratic regression cause or contribute before 50K (Expl 100K)	5-55K/ 1-50K	P(P)	
<u>75K tests</u>			
Integrated emissions from 5K to 75K	5-105K/ 5-75K	PP(PP)	P(P)
Quadratic regression 25,000 mile slope	5-105K/ 1-75K	P(P)	F(P)
Quadratic regression 50,000 mile slope	5-105K/ 1-75K	P(P)	P(P)
Quadratic regression 75,000 mile slope	5-105K/ 1-75K	P(P)	P(P)
Quadratic regression coefficient	5-105K/ 1-75K	P(P)	P(P)
Quadratic regression 75K/4K deterioration factor	5-105K/ 1-75K	P(P)	P(P)
Linear regression Post 50K slope	55-105K /55K-75K	P(P)	P(P)
Quadratic regression violation mileage <= 75K (Expl 100K)	5-105K/ 1-75K	P(P)	
Quadratic regression max % failing standard before 75K (Expl 100K)	5-105K/ 1-75K	P(P)	
Quadratic regression cause or contribute before 75K (Expl 100K)	5-105K/ 1-75K	P(P)	

Table 2b. Summary of the Ethyl and Ford fleet statistical tests for nitrogen oxides.

Description	Data used (Ford/ Ethyl)	EPA non-parametric All (Ethyl)	Weighted Average All (Ethyl)
<u>50K tests</u>			
Initial emissions	1K/5K		
equal car-means		PP(PF)	P(P)
unequal car-means		P(P)	P(F)
Initial emissions	5K/5K		
equal car-means		PP	P
unequal car-means		P	P
Change from 1K to 50K	5K,55K/		
equal car effects	1K,50K	PP(PP)	P(P)
unequal car effects		P(P)	P(P)
Change from 5K to 55K	5K,55K/		
equal car effects	5K,55K	PP	P
unequal car effects		P	P
Integrated emissions from 1K to 50K	5-55K/ 1-50K	PP(PP)	P(P)
Integrated emissions from 5K to 55K	5-55K/ 5-55K	PP	P
Linear regression slopes	5-55K/ 1-50K	P(P)	P(P)
Linear regression deterioration factors	5-55K/ 1-50K	P(P)	P(P)
Linear regression violation mileage <=50K (Expl <= 100K)	5-55K/ 1-50K	P(P)	
Linear regression max % failing standard before 50K (Expl 100K)	5-55K/ 1-50K	P(P)	
Quadratic regression 25,000 mile slope	5-55K/ 1-50K	P(P)	P(P)
Quadratic regression 50,000 mile slope	5-55K/ 1-50K	P(P)	P(P)
Quadratic regression coefficient	5-55K/ 1-50K	P(P)	P(P)
Quadratic regression 50K/4K deterioration factor	5-55K/ 1-50K	P(P)	P(P)

Table 2b. Concluded.

Description	Data used (Ford/ Ethyl)	EPA non-parametric All (Ethyl)	Weighted Average All (Ethyl)
Quadratic regression violation mileage <=50K (Expl 100K)	5-55K/ 1-50K	P(P)	
Quadratic regression max % failing standard before 50K (Expl 100K)	5-55K/ 1-50K	P(P)	
Linear regression cause or contribute before 50K (Expl 100K)	5-55K/ 1-50K	P(P)	
Quadratic regression cause or contribute before 50K (Expl 100K)	5-55K/ 1-50K	P(P)	
<u>75K tests</u>			
Integrated emissions from 5K to 75K	5-105K/ 5-75K	PP(PP)	P(P)
Quadratic regression 25,000 mile slope	5-105K/ 1-75K	P(P)	P(P)
Quadratic regression 50,000 mile slope	5-105K/ 1-75K	P(P)	P(P)
Quadratic regression 75,000 mile slope	5-105K/ 1-75K	P(P)	P(P)
Quadratic regression coefficient	5-105K/ 1-75K	P(P)	P(P)
Quadratic regression 75K/4K deterioration factor	5-105K/ 1-75K	P(P)	P(P)
Linear regression Post 50K slope	55-105K /55K-75K	P(P)	P(P)
Quadratic regression violation mileage <= 75K (Expl 100K)	5-105K/ 1-75K	P(P)	
Quadratic regression max % failing standard before 75K (Expl 100K)	5-105K/ 1-75K	P(P)	
Quadratic regression cause or contribute before 75K (Expl 100K)	5-105K/ 1-75K	P(P)	

Table 2c. Summary of the Ethyl and Ford fleet statistical tests for carbon monoxide.

Description	Data used (Ford/ Ethyl)	EPA non-parametric All (Ethyl)	Weighted Average All (Ethyl)
<u>50K tests</u>			
Initial emissions equal	1K/5K		
car-means		PP(PP)	P(P)
unequal car-means		P(P)	P(P)
Initial emissions	5K/5K		
equal car-means		PP	P
unequal car-means		P	P
Change from 1K to 50K	5K,55K/		
equal car effects	1K,50K	PP(PP)	P(P)
unequal car effects		P(P)	P(P)
Change from 5K to 55K	5K,55K/		
equal car effects	5K,55K	PP	P
unequal car effects		P	P
Integrated emissions from 1K to 50K	5-55K/ 1-50K	PP(PP)	P(P)
Integrated emissions from 5K to 55K	5-55K/ 5-55K	PP	P
Linear regression slopes	5-55K/ 1-50K	P(P)	P(P)
Linear regression deterioration factors	5-55K/ 1-50K	P(P)	P(P)
Linear regression violation mileage <=50K (Expl <= 100K)	5-55K/ 1-50K	P(P)	
Linear regression max % failing standard before 50K (Expl 100K)	5-55K/ 1-50K	P(P)	
Quadratic regression 25,000 mile slope	5-55K/ 1-50K	P(P)	P(P)
Quadratic regression 50,000 mile slope	5-55K/ 1-50K	P(P)	P(P)
Quadratic regression coefficient	5-55K/ 1-50K	P(P)	P(P)
Quadratic regression 50K/4K deterioration factor	5-55K/ 1-50K	P(P)	P(P)

Table 2c. Concluded.

Description	Data used (Ford/ Ethyl)	EPA non-parametric All (Ethyl)	Weighted Average All (Ethyl)
Quadratic regression violation mileage <=50K (Expl 100K)	5-55K/ 1-50K	P(P)	
Quadratic regression max % failing standard before 50K (Expl 100K)	5-55K/ 1-50K	P(P)	
Linear regression cause or contribute before 50K (Expl 100K)	5-55K/ 1-50K	P(P)	
Quadratic regression cause or contribute before 50K (Expl 100K)	5-55K/ 1-50K	P(P)	
<u>75K tests</u>			
Integrated emissions from 5K to 75K	5-105K/ 5-75K	PP(PP)	P(P)
Quadratic regression 25,000 mile slope	5-105K/ 1-75K	P(P)	P(P)
Quadratic regression 50,000 mile slope	5-105K/ 1-75K	P(P)	P(P)
Quadratic regression 75,000 mile slope	5-105K/ 1-75K	P(P)	P(P)
Quadratic regression coefficient	5-105K/ 1-75K	P(P)	P(P)
Quadratic regression 75K/4K deterioration factor	5-105K/ 1-75K	P(P)	P(P)
Linear regression Post 50K slope	55-105K /55K-75K	P(P)	P(P)
Quadratic regression violation mileage <= 75K (Expl 100K)	5-105K/ 1-75K	P(P)	
Quadratic regression max % failing standard before 75K (Expl 100K)	5-105K/ 1-75K	P(P)	
Quadratic regression cause or contribute before 75K (Expl 100K)	5-105K/ 1-75K	P(P)	

quantitative differences in the significance levels of the Ethyl and combined fleet analyses.

All versions of the cause or contribute test were passed at 50,000 miles and at 75,000 miles. Using only the Ford data up to 55,000 miles and the Ethyl data up to 50,000 miles, both Ford models passed the linear and quadratic versions of this test (the Explorer data beyond 55,000 miles was excluded but the regression curve was extrapolated up to 100,000 miles for that vehicle). Using all the data and fitting a quadratic regression, the cause or contribute test was passed for the combined fleet.

Hydrocarbons

Initial emissions tests

All five versions of the initial emissions test at 5,000 miles were significant for the combined fleet, indicating significantly different 5,000 miles emissions levels for the Howell EEE (or CHEV) and HiTEC 3000 vehicles. The same five tests were not statistically significant when the Ethyl fleet data at 1,000 miles was combined with the Ford fleet data at 5,000 miles. To interpret this result, note that the Ethyl fleet HiTEC 3000 vehicles would have accumulated 4,000 miles on HiTEC 3000 at this mileage but there was no HiTEC 3000 accumulation before the 5,000 mile tests for the Ford fleet. Note also that for both Ford fleet models, the HC emissions for the HiTEC 3000 vehicles were statistically significantly higher than the HC emissions for the CHEV vehicles using the statistical t test not assuming equal car-means, but the increased levels were not statistically significant using the statistical test assuming equal car-means. (The differences between these alternative test analyses is explained in Appendix 2A, Attachment C). These comments suggest that the failure of the initial emissions test at 5,000 miles is partly due to a small HiTEC 3000 HC increase for the Ethyl fleet from 1,000 to 5,000 miles and is also partly due to Ford's selection of vehicles with higher average initial HC emissions levels for HiTEC 3000 accumulation.

Integrated emissions tests

Three statistical tests were used to compare long-term integrated emissions: the EPA sign test, the EPA overall rank sum test, and the weighted average test. For the Ethyl fleet, the tests for the integrated emissions above initial levels from 1,000 to 50,000 miles were all failed, which has been attributed to the HiTEC 3000 increase in the first 4,000 miles of HiTEC 3000 accumulation. (See Appendix 2A). For the combined fleet, two alternative analyses were made using either matched mileages or matched mileage accumulation. The matched mileage version examined the integrated emissions above initial levels from 5,000 miles to 55,000 miles for both fleets. The matched mileage statistical tests were all passed. The alternative matched mileage accumulation tests examined the integrated emissions from 5,000 to 55,000 miles for the Ford fleet and from 1,000 to 50,000 miles for the Ethyl fleet. The matched mileage accumulation tests were all failed, corresponding to the Ethyl analysis. The passed matched mileages tests do not take into account any initial HiTEC 3000 effects over the first 4,000 miles of HiTEC 3000 accumulation, whereas the failed matched mileage accumulation tests take into account such initial effects. Therefore, these results provide further support for the contention in appendix 2A that all the failed adverse effects tests were failed due to the small, but statistically significant, HiTEC 3000 effect over the first 4,000 miles of HiTEC 3000 accumulation.

Quadratic slopes tests

Two statistical tests, the EPA sign test and the more powerful weighted average test, were used to compare quadratic regression slopes. In all cases the EPA sign test was passed for both the combined fleet and the Ethyl fleet. The weighted average test was passed for the Ethyl fleet but failed for the combined fleet in the case of the 25,000 mile quadratic regression slope test, both for the 50,000 mile analysis and the complete data analysis. It is important to realize that this test was not one of the original EPA tests (since the EPA tests used only linear regression analyses) and that these failures may also be attributable to the small HiTEC 3000 initial effect (The corresponding slopes tests at 50,000 and 75,000 miles were all passed.)

Carbon monoxide

All statistical tests were passed, both for the Ethyl fleet and for the combined fleet.

Nitrogen oxides

All of the seven sets of adverse effects tests and the cause or contribute test were passed, both for the Ethyl fleet and for the combined fleet. There were some differences for the initial emissions test as described in the next paragraph. Note that the initial emissions tests compare emissions levels prior to the mileage accumulation on the fuel additive and, therefore, significant results for this test do not indicate an adverse effect for the waiver fuel.

The five tests of initial emissions levels all showed no significant differences between the Howell EEE (or CHEV) and HiTEC 3000 fleets using the combined fleet data at 5,000 miles and using a combination of the Ethyl fleet data at 1,000 miles with the Ford fleet data at 5,000 miles. Note however that the Ethyl fleet analysis showed significance differences in nitrogen oxides at 1,000 miles based on the weighted average test not assuming equal car means and on the EPA overall rank sum test. At 5,000 miles, the Ford fleet Escorts selected for HiTEC 3000 accumulation showed significantly lower nitrogen oxides emissions whereas the Ford Explorers showed significantly higher nitrogen oxides emissions.

Appendix

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Ethyl Corporation HiTEC 3000 Fleet Testing Program

Initial Emissions Test
(assuming equal car-means)
Data Set ETHYL4S2 + FORD
Pollutant Hydrocarbons

Model	Emissions at 1000 mi (g/mi) EEE	(a) HT3	Sign	------ Rank Sum Test ------ Test Statistic	Mean	Sig.Level (%) (b)	T-test Sig.Level (%) (b)
D	0.285	0.279	-	15.5	12.0	61.00	40.15
E	0.099	0.104	+	21.0	18.0	70.00	68.38
F	0.168	0.167	-	20.0	18.0	81.80	95.63
T	0.189	0.207	+	7.0	18.0	9.40	13.33
C	0.123	0.129	+	14.5	18.0	58.80	41.94
G	0.101	0.100	-	20.5	18.0	81.80	91.65
H	0.182	0.168	-	26.0	18.0	24.00	15.41
I	0.173	0.162	-	22.5	18.0	58.80	43.62
A	0.101	0.114	+	58.0	72.0	41.89	18.78
B	0.149	0.175	+	37.0	72.0	4.33	8.03
Weighted Average (c)	0.161	0.160	-				75.11
Total				242.0	282.0	18.12	

EPA Sign Test: Observation of 5 '+' sign(s) in 10 trials rejects the hypothesis of no difference in initial emission levels between the fuels at the 100.00 percent significance level(b).

EPA Overall Rank Sum Test: The hypothesis of no difference in initial emission levels between the fuels is rejected at the 18.12 percent significance level(b).

Weighted Average Test: The hypothesis of no difference in initial emission levels between the fuels is rejected at the 75.11 percent significance level(b).

Notes:
a. Each figure is the mean of the 1,000 mile emissions tests (5,000 miles for models A and B).
b. The lower the significance level, the greater the evidence of a difference in initial emission levels between the fuels.
c. The weights for the weighted averages are proportional to 1988 sales figures.

Ethyl Corporation HiTEC 3000 Fleet Testing Program

Initial Emissions Test
(assuming equal car-means)
Data Set ETHYL4S2 + FORD
Pollutant Nitrogen Oxides

Model	Emissions at 1000 mi (g/mi) (a) EEE	Emissions at 1000 mi (g/mi) (a) HT3	Sign	Rank Sum Test: Test Statistic	Rank Sum Test: Mean	Rank Sum Test: Sig.Level (%) (b)	T-test Sig.Level (%) (b)
D	0.55	0.63	+	4.0	12.0	11.40	10.69
E	0.17	0.20	+	7.0	18.0	9.40	9.49
F	0.50	0.46	-	26.0	18.0	24.00	21.43
T	0.71	0.69	-	22.0	18.0	58.80	85.41
C	0.09	0.10	+	13.0	18.0	48.40	35.38
G	0.14	0.17	+	3.0	18.0	1.60	0.53
H	0.35	0.39	+	13.0	18.0	48.40	56.80
I	0.21	0.24	+	16.0	18.0	81.80	54.35
A	0.31	0.26	-	115	72.0	1.30	0.74
B	0.12	0.14	+	51.5	72.0	23.66	4.05
Weighted Average (c)	0.34	0.35	+				57.49
Total				270.5	282.0	70.07	

EPA Sign Test: Observation of 7 '+' sign(s) in 10 trials rejects the hypothesis of no difference in initial emission levels between the fuels at the 34.37 percent significance level(b).

EPA Overall Rank Sum Test: The hypothesis of no difference in initial emission levels between the fuels is rejected at the 70.07 percent significance level(b).

Weighted Average Test: The hypothesis of no difference in initial emission levels between the fuels is rejected at the 57.49 percent significance level(b).

Notes:
a. Each figure is the mean of the 1,000 mile emissions tests (5,000 miles for models A and B).
b. The lower the significance level, the greater the evidence of a difference in initial emission levels between the fuels.
c. The weights for the weighted averages are proportional to 1988 sales figures.

Ethyl Corporation HiTEC 3000 Fleet Testing Program

Initial Emissions Test
(assuming equal car-means)
Data Set ETHYL4S2 + FORD
Pollutant Carbon Monoxide

Model	Emissions at 1000 mi (g/mi) EEE	(a) HT3	Sign	------ Rank Sum Test ------ Test Statistic	Mean	Sig.Level (%) (b)	T-test Sig.Level (%) (b)
D	1.69	1.72	+	13.0	12.0	91.40	80.96
E	2.14	2.42	+	12.0	18.0	39.40	41.49
F	0.55	0.58	+	16.0	18.0	81.80	76.18
T	1.61	1.83	+	9.0	18.0	18.00	15.04
C	1.24	1.38	+	7.0	18.0	9.40	11.70
G	0.76	0.79	+	12.0	18.0	39.40	57.25
H	1.43	1.30	-	31.0	18.0	4.20	6.04
I	1.61	1.54	-	19.0	18.0	93.80	71.00
A	0.85	1.08	+	43.0	72.0	9.41	4.47
B	2.00	2.05	+	73.0	72.0	95.40	66.85
Weighted Average (c)	1.32	1.36	+				46.00
Total				235.0	282.0	11.62	

EPA Sign Test: Observation of 8 '+' sign(s) in 10 trials rejects the hypothesis of no difference in initial emission levels between the fuels at the 10.94 percent significance level(b).

EPA Overall Rank Sum Test: The hypothesis of no difference in initial emission levels between the fuels is rejected at the 11.62 percent significance level(b).

Weighted Average Test: The hypothesis of no difference in initial emission levels between the fuels is rejected at the 46.00 percent significance level(b).

Notes:
a. Each figure is the mean of the 1,000 mile emissions tests (5,000 miles for models A and B).
b. The lower the significance level, the greater the evidence of a difference in initial emission levels between the fuels.
c. The weights for the weighted averages are proportional to 1988 sales figures.

Ethyl Corporation HiTEC 3000 Fleet Testing Program

Initial Emissions Test
(not assuming equal car-means)
Data Set ETHYL4S2 + FORD
Pollutant Hydrocarbons

Model	Emissions at 1000 mi.(g/mi)(a) EEE	HT3	Sign ('+'= adverse HT3 effect)	T-test Significance Level (%)(b)
D	0.285	0.279	-	40.96
E	0.099	0.104	+	39.20
F	0.168	0.167	-	93.78
T	0.189	0.207	+	17.72
C	0.123	0.129	+	30.03
G	0.101	0.100	-	92.37
H	0.181	0.168	-	7.34
I	0.173	0.162	-	21.47
A	0.101	0.114	+	2.03
B	0.149	0.175	+	0.01
Weighted Average(c)	0.161	0.160	-	65.97

EPA Sign Test: Observation of 5 '+' sign(s) in 10 trials rejects the hypothesis of no difference in initial emission levels between the fuels at the 100.00 percent significance level(b).

Weighted Average Test: The hypothesis of no difference in initial emission levels between the fuels is rejected at the 65.97 percent significance level(b).

Notes:
a. Each figure is the mean of the car-means at 1,000 miles (5,000 miles for models A and B).
b. The lower the significance level, the greater the evidence of a difference in initial emission levels between the fuels.
c. The weights for the weighted averages are proportional to 1988 sales figures.

Ethyl Corporation HiTEC 3000 Fleet Testing Program

Initial Emissions Test
(not assuming equal car-means)
Data Set ETHYL4S2 + FORD
Pollutant Nitrogen Oxides

Model	Emissions at 1000 mi. (g/mi) (a) EEE	HT3	Sign ('+'= adverse HT3 effect)	T-test Significance Level (%) (b)
D	0.55	0.63	+	2.34
E	0.17	0.20	+	5.90
F	0.50	0.46	-	13.13
T	0.71	0.69	-	57.78
C	0.09	0.10	+	33.97
G	0.14	0.17	+	0.36
H	0.35	0.39	+	15.26
I	0.21	0.24	+	0.13
A	0.31	0.26	-	0.90
B	0.12	0.14	+	0.00
Weighted Average (c)	0.34	0.35	+	12.36

EPA Sign Test: Observation of 7 '+' sign(s) in 10 trials rejects the hypothesis of no difference in initial emission levels between the fuels at the 34.37 percent significance level(b).

Weighted Average Test: The hypothesis of no difference in initial emission levels between the fuels is rejected at the 12.36 percent significance level(b).

Notes:
a. Each figure is the mean of the car-means at 1,000 miles (5,000 miles for models A and B).
b. The lower the significance level, the greater the evidence of a difference in initial emission levels between the fuels.
c. The weights for the weighted averages are proportional to 1988 sales figures.

Ethyl Corporation HiTEC 3000 Fleet Testing Program

Initial Emissions Test
(not assuming equal car-means)
Data Set ETHYL4S2 + FORD
Pollutant Carbon Monoxide

Model	Emissions at 1000 mi.(g/mi)(a) EEE	HT3	Sign ('+'= adverse HT3 effect)	T-test Significance Level (%)(b)
D	1.69	1.72	+	83.98
E	2.14	2.42	+	6.85
F	0.55	0.58	+	64.32
T	1.61	1.83	+	19.15
C	1.24	1.38	+	6.29
G	0.76	0.79	+	6.93
H	1.43	1.30	-	5.89
I	1.61	1.54	-	55.15
A	0.85	1.08	+	1.14
B	2.00	2.05	+	54.41
Weighted Average(c)	1.32	1.36	+	30.95

EPA Sign Test: Observation of 8 '+' sign(s) in 10 trials rejects the hypothesis of no difference in initial emission levels between the fuels at the 10.94 percent significance level(b).

Weighted Average Test: The hypothesis of no difference in initial emission levels between the fuels is rejected at the 30.95 percent significance level(b).

Notes:
a. Each figure is the mean of the car-means at 1,000 miles (5,000 miles for models A and B).
b. The lower the significance level, the greater the evidence of a difference in initial emission levels between the fuels.
c. The weights for the weighted averages are proportional to 1988 sales figures.

Ethyl Corporation HiTEC 3000 Fleet Testing Program

Initial Emissions Test
(assuming equal car-means)
Data Set ETHYL4S2 + FORD
Pollutant Hydrocarbons

Model	Emissions at 5000 mi (g/mi) (a) EEE	HT3	Sign	Rank Sum Test: Test Statistic	Mean	Sig.Level (%) (b)	T-test Sig.Level (%) (b)
D	0.297	0.318	+	3.0	12.0	6.60	4.86
E	0.131	0.161	+	4.0	18.0	2.60	1.54
F	0.246	0.253	+	16.5	18.0	81.80	62.63
T	0.231	0.257	+	12.5	18.0	39.40	14.36
C	0.143	0.159	+	11.0	18.0	31.00	22.09
G	0.113	0.117	+	16.0	18.0	81.80	68.36
H	0.190	0.207	+	5.0	18.0	4.20	9.38
I	0.170	0.174	+	18.0	18.0	93.80	79.57
A	0.101	0.114	+	58.0	72.0	41.89	18.78
B	0.149	0.175	+	37.0	72.0	4.33	8.03
Weighted Average (c)	0.183	0.198	+				0.18
Total				181.0	282.0	0.07	

EPA Sign Test: Observation of 10 '+' sign(s) in 10 trials rejects the hypothesis of no difference in initial emission levels between the fuels at the 0.20 percent significance level(b).

EPA Overall Rank Sum Test: The hypothesis of no difference in initial emission levels between the fuels is rejected at the 0.07 percent significance level(b).

Weighted Average Test: The hypothesis of no difference in initial emission levels between the fuels is rejected at the 0.18 percent significance level(b).

Notes:
a. Each figure is the mean of the 5,000 mile emissions tests.
b. The lower the significance level, the greater the evidence of a difference in initial emission levels between the fuels.
c. The weights for the weighted averages are proportional to 1988 sales figures.

Ethyl Corporation HiTEC 3000 Fleet Testing Program

Initial Emissions Test
(assuming equal car-means)
Data Set ETHYL4S2 + FORD
Pollutant Nitrogen Oxides

Model	Emissions at 5000 mi (g/mi) EEE	(a) HT3	Sign	Rank Sum Test Test Statistic	Mean	Sig.Level (%) (b)	T-test Sig.Level (%) (b)
D	0.56	0.56	+	12.0	12.0	91.40	96.93
E	0.27	0.21	-	34.5	18.0	0.80	0.19
F	0.63	0.63	+	20.0	18.0	81.80	96.42
T	0.79	0.52	-	31.0	18.0	4.20	1.94
C	0.24	0.21	-	25.0	18.0	31.00	32.87
G	0.23	0.26	+	8.0	18.0	13.20	4.19
H	0.34	0.51	+	4.0	18.0	2.60	2.24
I	0.37	0.28	-	25.0	18.0	31.00	12.27
A	0.31	0.26	-	115	72.0	1.30	0.74
B	0.12	0.14	+	51.5	72.0	23.66	4.05
Weighted Average (c)	0.42	0.40	-				55.03
Total				326.0	282.0	14.14	

EPA Sign Test: Observation of 5 '+' sign(s) in 10 trials rejects the hypothesis of no difference in initial emission levels between the fuels at the 100.00 percent significance level(b).

EPA Overall Rank Sum Test: The hypothesis of no difference in initial emission levels between the fuels is rejected at the 14.14 percent significance level(b).

Weighted Average Test: The hypothesis of no difference in initial emission levels between the fuels is rejected at the 55.03 percent significance level(b).

Notes:
a. Each figure is the mean of the 5,000 mile emissions tests.
b. The lower the significance level, the greater the evidence of a difference in initial emission levels between the fuels.
c. The weights for the weighted averages are proportional to 1988 sales figures.

Ethyl Corporation HiTEC 3000 Fleet Testing Program

Initial Emissions Test
(assuming equal car-means)
Data Set ETHYL4S2 + FORD
Pollutant Carbon Monoxide

Model	Emissions at 5000 mi (g/mi) EEE	(a) HT3	Sign	------ Rank Sum Test ------ Test Statistic	Mean	Sig.Level (%) (b)	T-test Sig.Level (%) (b)
D	1.77	1.76	-	14.0	12.0	76.20	75.66
E	2.66	3.48	+	4.0	18.0	2.60	0.68
F	0.87	0.71	-	28.0	18.0	13.20	6.08
T	2.27	2.66	+	5.0	18.0	4.20	3.10
C	1.46	1.69	+	9.0	18.0	18.00	25.44
G	1.24	1.13	-	27.0	18.0	18.00	11.74
H	1.63	1.55	-	23.0	18.0	48.40	48.79
I	1.83	1.74	-	21.0	18.0	70.00	68.34
A	0.85	1.08	+	43.0	72.0	9.41	4.47
B	2.00	2.05	+	73.0	72.0	95.40	66.85
Weighted Average (c)	1.62	1.68	+				27.53
Total				247.0	282.0	24.20	

EPA Sign Test: Observation of 5 '+' sign(s) in 10 trials rejects the hypothesis of no difference in initial emission levels between the fuels at the 100.00 percent significance level(b).

EPA Overall Rank Sum Test: The hypothesis of no difference in initial emission levels between the fuels is rejected at the 24.20 percent significance level(b).

Weighted Average Test: The hypothesis of no difference in initial emission levels between the fuels is rejected at the 27.53 percent significance level(b).

Notes:
a. Each figure is the mean of the 5,000 mile emissions tests.
b. The lower the significance level, the greater the evidence of a difference in initial emission levels between the fuels.
c. The weights for the weighted averages are proportional to 1988 sales figures.

Ethyl Corporation HiTEC 3000 Fleet Testing Program

Initial Emissions Test
(not assuming equal car-means)
Data Set ETHYL4S2 + FORD
Pollutant Hydrocarbons

Model	Emissions at 5000 mi. (g/mi) (a) EEE	HT3	Sign ('+'= adverse HT3 effect)	T-test Significance Level (%) (b)
D	0.297	0.318	+	4.54
E	0.131	0.161	+	4.93
F	0.246	0.253	+	46.30
T	0.231	0.257	+	19.26
C	0.143	0.159	+	7.20
G	0.113	0.117	+	73.37
H	0.190	0.208	+	9.21
I	0.170	0.174	+	52.72
A	0.101	0.114	+	2.03
B	0.149	0.175	+	0.01
Weighted Average (c)	0.183	0.198	+	0.01

EPA Sign Test: Observation of 10 '+' sign(s) in 10 trials rejects the hypothesis of no difference in initial emission levels between the fuels at the 0.20 percent significance level (b).

Weighted Average Test: The hypothesis of no difference in initial emission levels between the fuels is rejected at the 0.01 percent significance level (b).

Notes:
a. Each figure is the mean of the car-means at 5,000 miles.
b. The lower the significance level, the greater the evidence of a difference in initial emission levels between the fuels.
c. The weights for the weighted averages are proportional to 1988 sales figures.

Ethyl Corporation HiTEC 3000 Fleet Testing Program

Initial Emissions Test
(not assuming equal car-means)
Data Set ETHYL4S2 + FORD
Pollutant Nitrogen Oxides

Model	Emissions at 5000 mi.(g/mi)(a) EEE	HT3	Sign ('+'= adverse HT3 effect)	T-test Significance Level (%)(b)
D	0.56	0.56	+	96.37
E	0.27	0.21	-	0.02
F	0.63	0.63	+	96.43
T	0.79	0.52	-	0.01
C	0.24	0.21	-	34.93
G	0.23	0.26	+	4.39
H	0.34	0.51	+	0.01
I	0.37	0.28	-	0.21
A	0.31	0.26	-	0.90
B	0.12	0.14	+	0.00
Weighted Average(c)	0.42	0.40	-	8.25

EPA Sign Test: Observation of 5 '+' sign(s) in 10 trials rejects the hypothesis of no difference in initial emission levels between the fuels at the 100.00 percent significance level(b).

Weighted Average Test: The hypothesis of no difference in initial emission levels between the fuels is rejected at the 8.25 percent significance level(b).

Notes:
a. Each figure is the mean of the car-means at 5,000 miles.
b. The lower the significance level, the greater the evidence of a difference in initial emission levels between the fuels.
c. The weights for the weighted averages are proportional to 1988 sales figures.

Ethyl Corporation HiTEC 3000 Fleet Testing Program

Initial Emissions Test
(not assuming equal car-means)
Data Set ETHYL4S2 + FORD
Pollutant Carbon Monoxide

Model	Emissions at 5000 mi.(g/mi)(a) EEE	HT3	Sign ('+'= adverse HT3 effect)	T-test Significance Level (%)(b)
D	1.77	1.76	-	77.08
E	2.66	3.48	+	2.22
F	0.87	0.71	-	0.50
T	2.27	2.66	+	3.45
C	1.46	1.69	+	12.61
G	1.24	1.13	-	6.18
H	1.63	1.55	-	18.46
I	1.83	1.74	-	45.70
A	0.85	1.08	+	1.14
B	2.00	2.05	+	54.41
Weighted Average(c)	1.62	1.68	+	8.74

EPA Sign Test: Observation of 5 '+' sign(s) in 10 trials rejects the hypothesis of no difference in initial emission levels between the fuels at the 100.00 percent significance level(b).

Weighted Average Test: The hypothesis of no difference in initial emission levels between the fuels is rejected at the 8.74 percent significance level(b).

Notes:
a. Each figure is the mean of the car-means at 5,000 miles.
b. The lower the significance level, the greater the evidence of a difference in initial emission levels between the fuels.
c. The weights for the weighted averages are proportional to 1988 sales figures.

Ethyl Corporation HiTEC 3000 Fleet Testing Program

Change in Emissions From 1,000 to 50,000 Miles
(assuming equal car effects)
Data Set ETHYL4S2 + FORD
Pollutant Hydrocarbons

Model	Change in Emissions (g/mi) from 1,000 to 50,000 mi(a)			------ Rank Sum Test ------			T-test
	EEE	HT3	Sign	Test Statistic	Mean	Sig.Level (%)(b)	Sig.Level (%)(b)
D	0.320	0.442	+	2.0	3.0	40.00	17.09
E	0.113	0.090	-	7.0	4.5	90.00	78.55
F	0.561	0.525	-	6.0	4.5	80.00	72.81
T	0.257	0.247	-	6.0	4.5	80.00	60.46
C	0.060	0.091	+	2.0	4.5	20.00	13.41
G	0.022	0.053	+	1.0	4.5	10.00	10.49
H	0.163	0.168	+	4.0	4.5	50.00	43.29
I	0.021	0.033	+	4.0	4.5	50.00	38.46
A	0.085	0.215	+	0.0	2.0	16.67	6.30
B	0.105	0.186	+	2.0	2.0	66.67	34.87
Weighted Average(c)	0.178	0.193	+				14.53
Total				34.0	38.5	24.65	

EPA Sign Test: Observation of 7 '+' sign(s) in 10 trials rejects the hypothesis of no adverse HiTEC 3000 effect at the 17.19 percent significance level(b).

EPA Overall Rank Sum Test: The hypothesis of no adverse HiTEC 3000 effect is rejected at the 24.65 percent significance level(b).

Weighted Average Test: The hypothesis of no adverse HiTEC 3000 effect is rejected at the 14.53 percent significance level(b).

Notes:
a. Each figure is the mean of the car-means at 50,000 miles (55,000 miles for models A and B) minus the mean of the car-means at 1,000 miles (5,000 miles for models A and B).
b. The lower the significance level, the greater the evidence of an adverse HiTEC 3000 effect.
c. The weights for the weighted averages are proportional to 1988 sales figures.

Ethyl Corporation HiTEC 3000 Fleet Testing Program

Change in Emissions From 1,000 to 50,000 Miles
(assuming equal car effects)
Data Set ETHYL4S2 + FORD
Pollutant Nitrogen Oxides

Model	Change in Emissions (g/mi) from 1,000 to 50,000 mi (a)			------ Rank Sum Test ------			T-test
	EEE	HT3	Sign	Test Statistic	Mean	Sig.Level (%) (b)	Sig.Level (%) (b)
D	-0.17	-0.15	+	2.0	3.0	40.00	36.27
E	0.23	0.19	-	6.0	4.5	80.00	77.17
F	0.65	0.31	-	7.0	4.5	90.00	87.24
T	0.07	-0.06	-	7.0	4.5	90.00	85.41
C	0.38	0.21	-	8.0	4.5	95.00	88.92
G	0.23	0.18	-	7.0	4.5	90.00	86.35
H	0.10	-0.04	-	7.0	4.5	90.00	85.28
I	0.25	0.15	-	7.0	4.5	90.00	81.64
A	0.08	0.17	+	0.0	2.0	16.67	10.74
B	0.04	0.12	+	1.0	2.0	33.33	27.56
Weighted Average (c)	0.23	0.10	-				99.54
Total				52.0	38.5	98.01	

EPA Sign Test: Observation of 3 '+' sign(s) in 10 trials rejects the hypothesis of no adverse HiTEC 3000 effect at the 94.53 percent significance level(b).

EPA Overall Rank Sum Test: The hypothesis of no adverse HiTEC 3000 effect is rejected at the 98.01 percent significance level(b).

Weighted Average Test: The hypothesis of no adverse HiTEC 3000 effect is rejected at the 99.54 percent significance level(b).

Notes:

a. Each figure is the mean of the car-means at 50,000 miles (55,000 miles for models A and B) minus the mean of the car-means at 1,000 miles (5,000 miles for models A and B).
b. The lower the significance level, the greater the evidence of an adverse HiTEC 3000 effect.
c. The weights for the weighted averages are proportional to 1988 sales figures.

Ethyl Corporation HiTEC 3000 Fleet Testing Program

Change in Emissions From 1,000 to 50,000 Miles
(assuming equal car effects)
Data Set ETHYL4S2 + FORD
Pollutant Carbon Monoxide

Model	Change in Emissions (g/mi) from 1,000 to 50,000 mi(a) EEE	HT3	Sign	------ Rank Sum Test ------ Test Statistic	Mean	Sig.Level (%)(b)	T-test Sig.Level (%)(b)
D	3.52	3.71	+	2.0	3.0	40.00	21.14
E	4.28	3.21	-	9.0	4.5	100.00	94.76
F	1.99	1.10	-	9.0	4.5	100.00	99.57
T	4.55	3.78	-	7.0	4.5	90.00	78.60
C	1.21	1.52	+	4.0	4.5	50.00	22.86
G	1.52	1.08	-	6.0	4.5	80.00	77.84
H	3.08	2.64	-	8.0	4.5	95.00	94.59
I	1.02	1.00	-	5.0	4.5	65.00	54.80
A	0.97	0.82	-	2.0	2.0	66.67	60.12
B	2.15	0.44	-	4.0	2.0	100.00	93.67
Weighted Average(c)	2.39	1.98	-				99.83
Total				56.0	38.5	99.62	

EPA Sign Test: Observation of 2 '+' sign(s) in 10 trials rejects the hypothesis of no adverse HiTEC 3000 effect at the 98.93 percent significance level(b).

EPA Overall Rank Sum Test: The hypothesis of no adverse HiTEC 3000 effect is rejected at the 99.62 percent significance level(b).

Weighted Average Test: The hypothesis of no adverse HiTEC 3000 effect is rejected at the 99.83 percent significance level(b).

Notes:
a. Each figure is the mean of the car-means at 50,000 miles (55,000 miles for models A and B) minus the mean of the car-means at 1,000 miles (5,000 miles for models A and B).
b. The lower the significance level, the greater the evidence of an adverse HiTEC 3000 effect.
c. The weights for the weighted averages are proportional to 1988 sales figures.

Ethyl Corporation HiTEC 3000 Fleet Testing Program

Change in Emissions from 1,000 to 50,000 Miles
(not assuming equal car effects)
Data Set ETHYL4S2 + FORD
Pollutant Hydrocarbons

Model	Change in Emissions from 1,000 to 50,000 mi (g/mi)(a) EEE	HT3	Sign ('+'= adverse HT3 effect)	T-test Significance Level (%)(b)
D	0.320	0.442	+	0.02
E	0.113	0.090	-	94.31
F	0.561	0.525	-	75.92
T	0.257	0.247	-	67.65
C	0.060	0.091	+	3.63
G	0.022	0.053	+	0.90
H	0.163	0.168	+	37.21
I	0.021	0.033	+	28.50
A	0.085	0.215	+	0.00
B	0.105	0.186	+	0.00
Weighted Average(c)	0.178	0.193	+	5.14

EPA Sign Test: Observation of 7 '+' sign(s) in 10 trials rejects the hypothesis of no adverse HiTEC 3000 effect at the 17.19 percent significance level(b).

Weighted Average Test: The hypothesis of no adverse HiTEC 3000 effect is rejected at the 5.14 percent significance level(b).

Notes:
a. Each figure is the mean of the car-means at 50,000 miles (55,000 miles for models A and B) minus the mean of the car-means at 1,000 miles (5,000 miles for models A and B).
b. The lower the significance level, the greater the evidence of an adverse HiTEC 3000 effect.
c. The weights for the weighted averages are proportional to 1988 sales figures.

Ethyl Corporation HiTEC 3000 Fleet Testing Program

Change in Emissions from 1,000 to 50,000 Miles
(not assuming equal car effects)
Data Set ETHYL4S2 + FORD
Pollutant Nitrogen Oxides

Model	Change in Emissions from 1,000 to 50,000 mi (g/mi)(a) EEE	HT3	Sign ('+'= adverse HT3 effect)	T-test Significance Level (%)(b)
D	-0.17	-0.15	+	26.22
E	0.23	0.19	-	93.26
F	0.65	0.31	-	100.00
T	0.07	-0.06	-	99.27
C	0.38	0.21	-	100.00
G	0.23	0.18	-	99.99
H	0.10	-0.04	-	99.88
I	0.25	0.15	-	99.91
A	0.08	0.17	+	0.03
B	0.04	0.12	+	0.00
Weighted Average(c)	0.23	0.10	-	100.00

EPA Sign Test: Observation of 3 '+' sign(s) in 10 trials rejects the hypothesis of no adverse HiTEC 3000 effect at the 94.53 percent significance level(b).

Weighted Average Test: The hypothesis of no adverse HiTEC 3000 effect is rejected at the 100.00 percent significance level(b).

Notes:
a. Each figure is the mean of the car-means at 50,000 miles (55,000 miles for models A and B) minus the mean of the car-means at 1,000 miles (5,000 miles for models A and B).
b. The lower the significance level, the greater the evidence of an adverse HiTEC 3000 effect.
c. The weights for the weighted averages are proportional to 1988 sales figures.

Ethyl Corporation HiTEC 3000 Fleet Testing Program

Change in Emissions from 1,000 to 50,000 Miles
(not assuming equal car effects)
Data Set ETHYL4S2 + FORD
Pollutant Carbon Monoxide

Model	Change in Emissions from 1,000 to 50,000 mi (g/mi)(a) EEE	HT3	Sign ('+'= adverse HT3 effect)	T-test Significance Level (%)(b)
D	3.52	3.71	+	24.48
E	4.28	3.21	-	99.83
F	1.99	1.10	-	100.00
T	4.55	3.78	-	96.14
C	1.21	1.52	+	18.29
G	1.52	1.08	-	99.61
H	3.08	2.64	-	90.23
I	1.02	1.00	-	53.42
A	0.97	0.82	-	81.92
B	2.15	0.44	-	100.00
Weighted Average(c)	2.39	1.98	-	99.99

EPA Sign Test: Observation of 2 '+' sign(s) in 10 trials rejects the hypothesis of no adverse HiTEC 3000 effect at the 98.93 percent significance level(b).

Weighted Average Test: The hypothesis of no adverse HiTEC 3000 effect is rejected at the 99.99 percent significance level(b).

Notes:
a. Each figure is the mean of the car-means at 50,000 miles (55,000 miles for models A and B) minus the mean of the car-means at 1,000 miles (5,000 miles for models A and B).
b. The lower the significance level, the greater the evidence of an adverse HiTEC 3000 effect.
c. The weights for the weighted averages are proportional to 1988 sales figures.